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THE JOURNAL
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ON THE FORMATION OF SPORANGIA IN THE GENUS STEMONITIS.

BY A. E. HILTON.

(*Read October* 26*th*, 1915.)

PLATE 1, FIGS. 1–4.

ONE of the most abundant forms of Mycetozoa in all parts of the world is Stemonitis; a genus easily recognisable by the dark-brown sporangia, usually 0·5 to 0·75 of an inch high, generally crowded together, which look something like diminutive bull-rushes, on slender black stalks.

Familiar as these are to some of our members, it is probable that not many have had an opportunity of watching the actual transformation of a plasmodium into sporangia. This process is so interesting that you will, I think, like to have a description of it, taken from my notes made at the time of a recent observation. By way of preface, it is well that I should remind you that in Stemonitis the stalk is continued upward as a columella nearly or quite to the apex of the sporangium. From this columella the capillitium branches in all directions, and surrounds the sporangium with a surface network of extremely delicate meshes, through which the spores finally escape.

In the middle of August last, after six weeks of frequent heavy rains, I took advantage of unusually favourable conditions, and

searched for Mycetozoa in the Highgate Woods. An old tree stump to which I came was hidden by the leaves of branches which had sprouted from it; but on drawing the branches aside I made a welcome discovery. Near the top of the stump were the blackened remains of an old and leathery fungus; and on these sooty-black and fairly level platforms there were several patches of milk-white plasmodium which appeared to have oozed from the stump. The smallest patch was about 0·125 inch, and the largest about 1·125 inch in diameter; all being probably portions of the same plasmodium, which had found its way to the surface of the fungus by different channels and in varying quantities. Carefully severing the fungus from the stump, I transferred the treasures to my collecting-box. It was on the stroke of noon, and I had found them only just in time, as developments began almost immediately.

The plasm was in a semi-fluid condition, and consequently the patches were, at first, of a somewhat rounded and flattened cushion-shape (Pl. 1, fig. 1). The surfaces soon assumed a frothy appearance, and in about a quarter of an hour the cushions were covered with bubble-like hemispheres, of uniform size, somewhat translucent, close together, and slightly angled by mutual pressure. In this condition they were charming objects, resembling nothing so much as tiny blanc-manges, moulded into perfect shape (Pl. 1, fig. 2).

Here let us pause a moment to inquire what, so far, had really happened. A simple question, but in biology everything is complex, and of complicated phenomena only abbreviated accounts can be given. Bear in mind that in the Mycetozoa, spore-formation is essentially a process of rejuvenation by purification. A plasmodium about to form sporangia includes not only its own proper nuclear elements and their cytoplasm, but also an excess of fluid, and substances, more or less dissolved, which have to be either secreted or excreted before this renewal of youth can be effected. The excess fluid gradually evaporates, and of the superfluous substances the cruder elements are

the first to be precipitated. In the case before us it is evident that secretion and evaporation had sufficiently advanced for the partially purified plasm, in accordance with the laws of colloidal physics, to begin dividing into smaller masses; each separating mass being indicated by one of the surface hemispheres, and furnishing the material for a distinct sporangium. While these results were coming to light, other developments commenced which were to appear later on.

To proceed. By 4 p.m. the whiteness of the upper surfaces had changed to a creamy tint, or more correctly to a very light pale brown. Also the area covered by the hemispheres was contracting and at the same time rising to a higher elevation. That is to say, each aggregation of plasm-masses was growing taller and beginning to assume a somewhat conical shape (Pl. 1, fig. 3). The lower two-thirds of the plasm had become columnar; the mass immediately beneath each surface hemisphere being now at the summit of a pillar, forming as it were its capital. The pillars were milky-white, semi-transparent, and of smaller circumference than the tinted capitals which crowned them. This means that although the plasm masses of the upper third were still crowded together, there were clear spaces between the pillars which supported them. The artistic effect was strangely beautiful. Each cluster of the half-formed sporangia now seemed to be a miniature temple of surprising loveliness not easily forgotten when once seen.

In another half-hour black stalks were visible at the centres of the pillars. At 6 p.m. the sporangia, now obviously those of Stemonitis, were nearly half an inch in height; and by 8.30 the whole of the plasm had risen clear of the fungus, and was resting on a forest of stalks, 0·125 inch long. On the surface of the fungus from which it had ascended, the plasm had left a whitish sedimentary deposit, which formed a membranous hypothallus; and this subsequently assumed a silvery hue. On the tops of the clusters of sporangia some watery plasm was all that remained of the hemispheres, which had

melted into, and been absorbed by, their respective pillars, as the sporangia lengthened upwards to their full height. At this stage the general appearance of each cluster suggested a diminutive canvas tent with a flattened top, spreading considerably towards the bottom, and held in position by black cords (Pl. 1, fig. 4). Very striking indeed were these successive developments.

Again we pause to ask, as before, what had really happened. What were the inward facts of which these metamorphoses were the outward signs? The essential process, the clarification of the plasm, was evidently proceeding apace. That was shown by the excretion of the hypothallus and the secretion of the stalks; and was further emphasised by the alteration in the colour of the plasm. For the creamy or light-brown tint now prevailing indicated that finer secretions from purer plasm were also being deposited to form the branching capillitia and the delicate superficial nets enveloping the sporangia. The elimination of these materials, concurrently with loss of fluid by evaporation, would inevitably alter the physical strains of the colloidal plasm; and the formation of the columns, and the climbing of the plasm up the stalks, in spite of gravitation, was plainly a shrinkage movement caused by a progressive strengthening of the surface tensions. Thus far, however, the processes were all preliminary; the most important change was impending.

At 10 p.m., ten hours after the emergence of the plasmodium from the tree-stumps, the sporangia had practically attained their ultimate shape, and were a shade darker, though still of a light brown or buff colour. By 8 a.m. next day they were nearly black; and by 8 p.m. on that date they were a dark purplish brown. The colour became a little lighter, or rather browner, as the sporangia subsequently dried off; but the beauty had gone.

What had occurred in this closing stage? The living plasm had lent its charm to all the previous phases. Why had it now

withdrawn from sight behind so dark and dull a screen? What had happened was this: it had achieved its purification, gained its end, and passed into a state of rest; ready, on reawakening under suitable conditions, to recommence its vital activities with all the vigour of youth perfectly renewed. In other words, the extrusion of its impedimenta had made it possible for the nuclear elements of the plasm to adjust themselves to the process of spore-formation. Immediately before the actual formation of spores, the multitudinous nuclei in the plasm greatly increase in number, the clarification of the plasm clearing the way for the growing nuclei to divide. An equilibrium of balanced colloidal conditions then ensues; the nuclei becoming suspended in geometrical order, and at equal distances from each other, throughout the entire mass. This is brought about by the mutual opposition of their radiating energies. Each nucleus thus becomes the centre of an individual spore. By a final act of purification the remaining impurities are expelled to the boundaries of the spheres of nuclear influence, where they harden into spore-cases. This is followed by further drying and shrinking; each case containing its nucleated plasm-speck is separated from the rest, and the process of spore-formation is complete. The life of an individual plasmodium passes into the lives of innumerable spores; the problem of individuality, as thus presented by the Mycetozoa, being one you can ponder at leisure.

A word of warning is perhaps necessary. In principle, the methods of spore-formation are analogous throughout the group; but not always do the inward processes find such striking expression as in the forms we have been studying. We must not, however, regard these forms as having any special or exceptional significance. They are but transient phases of the plastic plasm, which arrest us by their beauty and disappear. Even the beauty is in this, as in other cases, the lover's gift; and to the numberless spores it matters not at all what the shape of the sporangium may be. The delicate network of the capillitium

of Stemonitis is a good object for the microscope; but it is only a by-product, and of no biological importance. When the spores disperse to fulfil their next function, all other structures are left behind to perish; but we know that if the life which created them survives, the forms we have admired will reappear.

Description of Plate I.

Fig. 1. Pulvinate form of plasm-masses at 12 noon. × 3.
,, 2. Frothy surface appearance at 12.15 p.m. × 3.
,, 3. Semi-columnar form at 4 p.m. × 3.
,, 4. Cluster of stalked sporangia developed by 8.30 p.m. × 3.

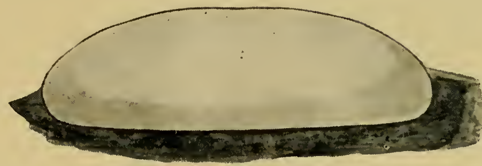

Fig. 1.

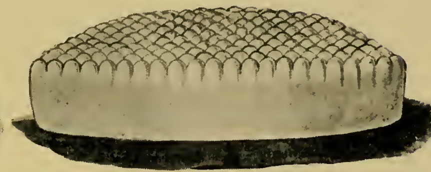

Fig. 2.

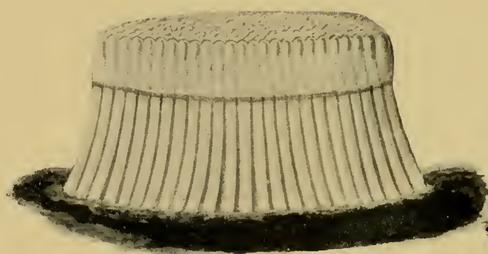

Fig. 3.

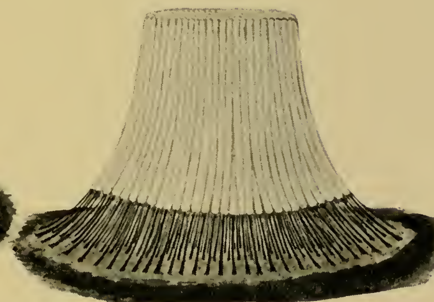

Fig. 4.

A. E. Hilton, *del ad nat.*

Mycetozoa.

Phases in the formation of Sporangia of Stemonitis. × 3.

ON A SPECIES OF ALEURODES.

By James Burton.

(*Read December 28th*, 1915.)

I am desirous of bringing under your notice a few facts concerning an interesting little fly belonging to the genus Aleurodes. I am not quite sure of the specific name, not having access to detailed and descriptive lists of the species, but probably it is *A. brassicae*, a not uncommon form and, as its specific name implies, found on cabbages. The definition of the family given in the *Cambridge Natural History* is as follows: "Minute insects with four mealy wings; seven-jointed antennae; two jointed feet, terminating in two claws and a third process." It is not quite a new subject to the Club, as Mr. Lewis some years ago described and beautifully figured a species that had been sent to him from South Africa. This was a new species, and was named by Mr. Maskell—an authority on the group—*Aleurodes asparagi*, as it was found on a species of Asparagus, grown in Natal. Mr. Lewis's paper will be found in vol. vi. 2nd series of the *Journ. Q. M. C.* The paper was read in April 1895, and is most useful, in fact it is the only description in any detail with which I am acquainted. Mr. Lewis has been so kind as to lend me some of his mounted specimens.* The pupae of *A. asparagi* are especially interesting, as they differ in several important respects from those which I have found. These pupae have handsome plumes composed of a wax-like substance secreted by the insect, arranged in rows along the back and sides; these are entirely absent in my specimens, which have only a kind of frill—of the same structure, however—

* Mounted preparations of *Aleurodes brassicae* were exhibited as well as Mr. Lewis's preparation of *A. asparagi* from South Africa.

round the lower edge of the body; this is also present in *A. asparagi*, though hidden by the more handsome side plumes.

The occurrence which made me wish to bring the subject before you has only recently happened, and is so interesting that it seems worth recording.

During most of the summer a fuchsia remained on an inside window-ledge. In September it was condemned to the garden, and on carrying it out a quantity of honey-dew was noticed on many of the leaves. As there is a connection between the presence of honey-dew and certain fungi, and this being of interest to me, I at once looked the plant over carefully. As soon as the leaves were disturbed, several of these little white flies rose up, and they proved to be quite numerous on the plant. Ever since at intervals it has been possible to find a few on the leaves, and only yesterday, without any thorough search, two living Aleurodes were detected.

The fly is a very small and fragile creature; when living it is almost exactly 1 mm. long. It has an orange-coloured body, with well-marked head, thorax and abdomen. There are two dark-pink compound eyes, which are worth notice; they are oval in outline, each with a constriction across the long axis, but which does not completely divide them. There is a small simple eye above each of the compound ones. The antennae are seven jointed, the two basal segments larger than the others. There are four membranous wings, without nervures; apparently these, like the body, legs and antennae, are thickly covered with a mealy white substance, and there seems little doubt that this is a waxy exudation. The legs and feet are slender, the tarsus with two joints, and terminating with two rather long and slender claws, and a third process. Beneath the head is a curved sword-like piercing and sucking rostrum, almost the length of the thorax; the end is sharp pointed and dark in colour. With this the insect pierces the leaf of the host plant and sucks the juices, just as do the Aphides, the well-known green flies, and the nearly

related Coccidae or Scale-insects. The meal with which the whole insect is covered is a troublesome feature in mounting, as it resists water or weak spirit, and the use of stronger spirit usually results in the waxy secretion being removed at the last stage of the mounting and it then looks like dirt in the finished slide. With turpentine, etc., for balsam mounts it is dissolved. On the dorsal aspect of the last segment of the body there is a peculiar organ of some interest. It is very well shown in the plates illustrating Mr. Lewis's paper referred to above, but it is not easy to make out distinctly in mounted specimens. The Aphides, as is well known, secrete a large quantity of the sticky sweet substance known as "honey-dew," and the Aleurodes do the same. In most species of Aphides the organs which emit this substance are easily seen, and consist of two tubes near the end of the body set one on each side pointing upwards and backwards. It has been suggested that possibly the organ in Aleurodes on the last segment may serve the same purpose, but it seems scarcely likely considering its structure. It is formed of a short, hollow, crater-like base, from which projects a sort of papilla covered with hairs. On one occasion I was examining a leaf with many pupae upon it, when I was called away for about an hour. On my return a fly had emerged, its wings were not quite perfectly extended. It was covered with a glass and a drop of chloroform was run under, and almost immediately that the creature felt its influence it emitted a large drop of honey-dew. It was impossible to see the precise spot from which it came, but it was between the wings towards the anal end of the abdomen, and might have come actually from the anus.

Aleurodes was formerly classed with the Scale-insects, but the genus now forms a separate family under the name of Aleurodidae, placed between the Aphides and the Scale-insects. There are several reasons for this arrangement. The Aphides are not winged except in the sexual stage. In the Scale-insects the male has two wings only, the female none, while the imago of Aleurodes has

always four wings, in both male and female. But the chief difference is in the metamorphosis which the insect passes through. As is well known, much the greater number of Aphides are produced viviparously from unfertilised females, and no true metamorphosis occurs, though there is some change as the insect develops.

Dr. Sharp in the *Cambridge Natural History*, vol. vi., says:

"These minute insects are at present a source of considerable perplexity owing to the curious nature of their metamorphosis, and the contradictory accounts given of them. In the earlier stages they are scale-like and quiescent, being fixed to the underside of the leaf. The French authors Signoret and Girard state that the young are hatched having visible appendages and segmentation, but that after they are attached to the leaf the organs gradually atrophy. Maskell states the opposite, saying that the organs in the earliest stages are not usually recognisable, but become visible after the growth of the insect.

"Heeger states that the larva undergoes three ecdyses, and he gives the figures reproduced in the *Cambridge Natural History*. If he is correct it would appear that the nymph undergoes a great development. Réaumur, on account apparently of their great metamorphosis, treated the species known to him as lepidopterous, though he correctly pointed out their distinctions. At present we can only conclude that the Aleurodidae undergo a metamorphosis of a kind peculiar to themselves, and requiring renewed investigation. . . . .

"Maskell has increased the number of species to about sixty. We have three or four in Britain, one of which, *A. brassicae*, is extremely abundant on various kinds of cabbage in certain years."

I have quoted this account because, so far as the species which I have had under observation are concerned, I am able to supply some definite information on doubtful points.

A writer in *The Journal of Micrology* says:

"Another lodger is a very pretty moth-like fly. Its wings are pure white except for a dusky marking on each; they are covered

with exceedingly small scales which are fastened to the membrane with a 'quill' as in the moths. When the fly is ready to deposit her eggs, she selects a depression in the under side of an outer cabbage leaf, and then lays from six to twelve dark-coloured eggs in a group, while all around are strewn scales from the wings and body. And yet the fly looks none the worse! What happens next is not quite clear, but a white fringe appears all around the egg which fastens it to the leaf; and upon turning it over I find a tiny grub underneath, furnished with six legs, each armed with a bent claw and a long stiff hair. The abdominal segments can just be distinguished. From the thorax (?) projects a long, straight sucker, which is driven deep into the leaf. I am not quite sure whether the insect uses its egg shell for its first covering, or whether it makes a scale; but in a day or two the fringe disappears, and the grub and its covering grow rapidly, until it looks like a tiny Brazil nut, with the sharp edge upwards. Then one day the 'nut' splits along the edge and the perfect imago emerges. During the time the grub was feeding it moved only about half an inch from the spot where was laid the egg from which it developed. This fly is known as the Cabbage Powdered-wing Fly—*Aleurodes proletella.*"

This description tallies in most respects with what I have observed. First, however, it may be said that the mealy substance does not consist of scales with a quill as in the moths. I have been very careful in the matter; the mealy substance consists of very short curved rod-like pieces. One might almost consider them to be minute rods of wax forced out from pores and curving in the process. There was nothing like a scale or a quill to fasten it. In *A. brassicae* the egg was a short cylinder slightly curved with rounded ends, pale yellow in colour, with a darker orange spot at one end. The young larva has legs, antennae, two pink eyes, some few hairs or bristles but not of great length; it is of a pale transparent yellow with an orange-coloured patch, segments just visible; it moves feebly, and probably does not move

far away from its first position. In the next stage it has settled down, and thrown out a delicate fringe of waxy filaments round the lower edge of the body, which seems to fix it to the leaf. It now much resembles a Scale-insect. From this stage it appears to increase in size, and develops a number of long glass-like brittle processes from the back and sides, about twelve in number, and becomes box-like, oval in outline, with sides of considerable depth; the side of the box is composed chiefly of the wax fringe, and the edges are ornamented with curved glass-like hairs, shorter than those already spoken of. The imago becomes gradually more clearly visible in this which is the pupa stage; at last the top of the box is rent, usually across, but sometimes the lid is forced off at one end, and the fly emerges a beautiful and delicate little object, especially for the binocular microscope. I have tried to dry them for opaque illumination, but they shrivel up and become distorted and useless.

Like the green flies and the Scale-insects, no doubt Aleurodes does damage to plants by sucking their juices, and when the number present is great of course the damage would be considerable. But another, though somewhat indirect injury results from the presence of any of these insects. The honey-dew secreted falls chiefly on the upper surfaces of the lower leaves of the plants upon which they are living, or upon the leaves of any plants growing beneath them, and this honey-dew forms the substratum upon which one or more species of fungi flourish. Mr. Massee in his *Text-book of Plant Diseases* refers to the sooty mould following the white fly *Aleurodes citri*. One species is recorded as attacking coconut trees, and is named *Aleurodes cocois*. *A. brassicae* and *A. proletella* both occur on cabbages, while *A. citri* is very injurious in many parts of the world on trees of the Citrus group, doing great damage to orange and lemon fruit. Mr. Lewis's specimens occurred on a species of Asparagus, apparently grown for ornamental purposes in Natal. The sooty fungus *Fumago vagans* is extremely common, flourishing on the honey-dew secreted by the

green flies on very many kinds of trees and shrubs. In the autumn the lower leaves of limes, oaks and shrubs growing under them may be seen to be covered with a black soot-like deposit, which upon examination proves to be a fungus. It is opaque and of course obstructs the influence of the light on the chlorophyll in those leaves on which it appears. Oranges which usually arrive in this country in the spring are often covered with a black deposit near the remains of the flower; this is some species of Meliola or Capnodium, fungi which flourish on the excrement and secretion of the Scale-insects and no doubt of Aleurodes also.

In a book published last spring, *Insects and Man*, there is a long account of almost heroic efforts which have been made to reduce the loss caused to the Citrus growers of Florida by the depredations of *Aleurodes citri*, and the injury caused by the fungus which almost always develops on the honey-dew secreted by the fly. It is there stated that " the fungus does more harm to the plants than the insects themselves, pervading, as it does, not only the leaves, but the branches and even the fruit itself. More than 45 per cent. of the Citrus groves of Florida are infested with the fly, estimated to cause a loss of from 45 per cent. to 50 per cent. of the value of an orange crop."

From experience obtained in other cases it was determined to endeavour to find some insect, such as an ichneumon fly, or some species of lady-bird, which would prey upon the Aleurodes. The American Congress made a special grant towards a world-wide search. At last the commissioners found in India a small reddish-brown lady-bird about one-tenth of an inch long, and also a minute hymenopterous parasite, both of which preyed upon the Aleurodes. Efforts were made to get a supply of these foes upon the scene, but, notwithstanding every endeavour, some difficulty always arose which rendered it unsuccessful. Wardian cases were made in which to bring over young citrus trees, with the Aleurodes fly upon them, infested with the parasite; and also the lady-birds from

which so much was hoped, but only a few of the insects survived the journey. In one instance it was found that twenty-eight lady-birds had survived the journey; they arrived in December, but at the end of the winter only two were still alive. On examination these proved to be both females, so obviously not much in the way of reproduction could be expected. The whole account is deeply interesting; and it is to be hoped that sooner or later the attempt will receive the reward it merits, even if the result should be an extermination of the little Aleurodes fly.

THE COLLECTION AND PRESERVATION OF DESMIDS.

By G. T. Harris.

(*Read January 25th,* 1916.)

Communicated by James Burton.

The publication by the Ray Society of Prof. West's *Monograph of the British Desmidiaceae* has induced so many microscopists to concentrate their attention on this beautiful group that I feel no apology is needed for describing methods that have proved advantageous in my hands, both in collecting the material and in dealing with it when collected. I am aware that the literature dealing with the collection and preservation of desmids is not inconsiderable, and that formulae for mounting media have been given with a generosity only equalled by their shortcomings ; yet the hope that one may perhaps contribute some method that shall prove more or less useful overcomes the reluctance to add yet further to the burden of contributed matter on the subject.

The complaint not infrequently made by the uninitiated of their lack of success in obtaining desmids may be due more to their method of collecting than to the absence of desmids. The orthodox ring-net will, of course, collect a considerable number of unattached specimens, but the bulk of desmids are usually attached by their gelatinous secretion to objects that are more or less stationary, hence the ring-net misses these unless it happens to brush them off and they find their way into it. The habitats of desmids also are probably of much greater diversity than the average microscopist realises, and vary from a roadside ditch with merely a few inches depth of water in it to a moorland tarn ; from the wet, moss-grown trunk of a tree to the dripping face of some perpendicular rock. Last spring in a roadside ditch near Sidmouth, with barely a quarter of an inch depth of water, was a perfect film formed of individuals of *Closterium Ehrenbergii*, in extremely fine condition. The only way to collect them was to

skim them off the bottom with a spoon, collecting as little mud as possible in doing so. On another occasion when crossing a boggy field in East Devon, a small cup-like hollow was noticed filled with bog water that had a greenish appearance; on filling a 3 in. by 1 in. tube with the water the colour was found to be due to *Euastrum oblongum* in such prodigious numbers as almost to allow of the term "desmid soup" being applied to the gathering. These are the "pure gatherings" the authorities refer to. My fate, however, has usually been to meet them so closely associated with their environment that the purity of the gathering from a mounter's point of view has not confirmed the appropriateness of the term. It is, of course, easy to understand these congested associations of individuals of one species by reflecting that when conditions are favourable, and division is actively taking place, concentration must result unless the water has sufficient motion to distribute the plants.

Wherever a thin growth of conferva spreads itself on stones in slow-running streams, or over the surface of submerged woodwork, desmids may be expected to occur, and the film should be carefully removed and bottled. The flocculent matter that collects around the stems of aquatic plants in ponds and the back-waters of streams may be collected by Prof. West's trick of clipping the stem below the surface of the water between the closed fingers and making of the hollowed hand a cup in which the flocculent matter is collected by drawing the hand upwards. Masses of Spirogyra may be lifted out of the water, drained, wrapped in waterproof paper and deposited in a vasculum; desmids will generally be found entangled among their threads and may be removed at home. Mosses from wet tree trunks are best separated and the stems washed vigorously in a dish, when the desmids, if present, will be washed away from the moss. Generally speaking, moss habitats are not prolific hunting-grounds, the species occurring amongst them being principally those of the genus Mesotaenium. Swift mountain streams at first sight do not strike one as likely hunting-grounds, but the confervae attached to the rocks often contain many good species. My introduction to the comparatively rare *Closterium didymotocum* took place at the head waters of the River Teign on Dartmoor, where it occurred

somewhat plentifully, growing among the algae on the rocks, and associated with it large numbers of *Netrium Digitus*. It is obvious that the ring-net is of little use in such localities; the better way is to collect a tuft of algae by hand and wrap it in waterproof paper or place it in a tube filled with the water in which it grows.

If the collecting excursion be one of a day's duration only, the ordinary supply of tubes and bottles will suffice for all the material likely to be collected, and it may be brought home in the water in which it was found; but with an extended excursion away from home the number of bottles and tubes necessary for several weeks' collecting would mean a considerable amount of very careful packing. In addition, to bring home the bottles filled with the miscellaneous gatherings that are more or less inevitable, would be to invite certain disaster. Aquatic larvae will intrude into gatherings of desmids, and when bottled will die, and when dead will decompose, and the opening of such a collection at home some weeks later is not a fragrant operation. When planning a collecting trip of some five or six weeks' duration over Dartmoor I duly considered these drawbacks and sought some way of obviating them. After considering and rejecting several methods I decided to preserve the gatherings on the spot. My object was to work a certain district of the moor thoroughly, and to keep the gatherings as far as possible separate. The method I finally adopted, and which gave me complete satisfaction, was to obtain material from each bog, moor-pool, etc., and kill and fix the plants (and incidentally what was with them) on the spot. The details of this method may be of interest, and possibly of use, to some of the members.

A small funnel to support the filtering material is essential. This may be of ebonite, or tin; glass is inadvisable. For my own use I make them out of a piece of "ferrotype" metal, cut to the shape of the collector's net; three small holes cut in one side and three metal buttons fixed on the other enable the piece of metal to be converted at once into a filter support, which unbuttoned when not required becomes again a flat piece of metal occupying little space in the collecting-case. After trying many materials for filtering purposes I found nothing so good as chamois

leather. Even the filter papers specially made for filtering under pressure proved useless after a little use. Chamois leather has the great advantage that it allows of the residue being entirely removed with a spatula without the risk of tearing it and thus losing part of the collection. Any material that I have tried becomes slow in action when thoroughly saturated with water, and for this reason, if considerable collecting is done during the day, two, or even three, filters in operation at the same time are not too many. At least this was my experience when collecting on Dartmoor. My collecting-case for a day's work contained a dozen 3 in. by 1 in. tubes, the corks numbered in large numerals of white paint 1 to 12. Smaller tubes also were carried, and several 4-ounce wide-mouthed bottles. A blunt-edged knife or spatula for scraping off the residue was also carried, and a small supply of waterproof envelopes, about "court" size, for containing tufts of algae. The ring-net for bog collecting is indispensable, but after breaking six tubes in one day's collecting against submerged and hidden stones, I substituted for the glass tube attached to the net a zinc one. It really is not necessary to examine the contents with a lens, as it would be quite impossible to make any useful determination of the smaller species. On arriving at the bog I propose to work I select a suitable furze or heather bush contiguous to the bog and support my filter funnels securely in the topmost twigs so that drainage from the filters is unimpeded. The bog is now worked with the net and each tubeful collected transferred to the filters. Tufts of sphagnum may also be collected and the bog water contained in them squeezed into the filter to extract any desmids growing amongst them. When sufficient has been collected the residue is drained, then scraped off the chamois leather with the spatula and transferred to one of the numbered tubes; the name of the bog and whatever details are deemed necessary being entered against a corresponding number in a notebook. After the residue has been placed in the tube, clear bog water is added and about 4 c.c. (for a 3 in. by 1 in. tube) of the following killing and fixing solution:

Cupric sulphate (10-per-cent. solution) . . .	100 c.c.
Mercuric chloride (saturated solution) . . .	10 c.c.

Exactitude in the amount of preservative added is unnecessary,

and a little practice soon enables one to estimate about the right amount. In connection with this method of filtering in the field I have one more accessory to mention which may appear trivial to those unaccustomed to moorland collecting. This takes the form of a light wand about 6 feet in length, which is stuck in the bushes containing the filters; a hazel stem cut from the hedgerow on the way answers every purpose. The object is to enable one to find the filters readily when collecting operations lead one unconsciously some distance away. It may appear unnecessary, and I do not insist on it; but one morning on Dartmoor when working a somewhat extensive bog it took me an hour's diligent searching to find the heather bush containing my filters, which were eventually found on quite the opposite side of the bog from the one about which I had been searching. Several collecting articles I have never found, owing largely to the similarity in appearance among heather bushes when dotted about extensive moors.

As regards the results obtained by the collecting method just described, when I state that from about 10 c.c. of material taken from one small unimportant bog I obtained over one hundred species and varieties it will be seen that it is a very practical and productive method. From large, old-established bogs the result in individuals and species is really very remarkable, and from the collections made during a summer excursion on the north-eastern part of Dartmoor I have obtained four hundred species and varieties, and have still a large quantity of material remaining unexamined. For the benefit of those unaccustomed to moorland collecting a warning may be given as to the character of the bog. If a collecting excursion were made to a moor like Dartmoor in late spring or early summer a good deal of disappointment might be experienced from working impermanent bogs. These form during the winter seasons, and as summer advances dry up. The collecting in them is seldom remunerative. It is the old, deep and permanent bogs that yield the best collections, and one of the tests that I apply to a bog is the presence or absence of *Sphagnum cuspidatum*, this species rarely occurring in any but permanent bogs. Moorland pools are always worth the collector's attention, and often yield quite different species from

those of the bogs. A feature that strikes one in connection with them is that they are often occupied almost exclusively by one, or at least a very few, species. One moorland pool I examined on Dartmoor was so filled with *Staurastrum brachiatum* that from every part of it the net was crowded with specimens, and another small pool was quite green with the rod-like threads of *Hyalotheca dissiliens*, and practically nothing else occurred there. Yet another pool was the exclusive preserve of *Xanthidium variabile.*

It is obvious that by adopting this method of collecting, bottles might be altogether dispensed with, the residue of the filtering being saturated with the preservative, drained and wrapped in waterproof paper. This would be a very convenient method for anyone wishing to cover a considerable district during a holiday without being encumbered with storing appliances.

One drawback is associated with the material collected in the manner just described; it is so concentrated, and is such a heterogeneous mass, that when it comes to mounting the desmids contained in it the difficulty of isolating them from the debris of sphagnum, the aquatic larvae, rotifers, entomostraca and a multitude of denizens that constitute a bog fauna, the mounter may be excused if he loses patience with such material. Unfortunately I have no remedy to offer, in spite of the many endeavours to devise some method which should, even partially, separate the desmids from their surroundings. The best method I can suggest, and the one I myself use, is to take a small portion of the material in a pipette, place it in a shallow tray and well dilute it with water; then with a very fine pipette the desmids can be picked out with a minimum of bog debris. They are transferred to a watch-glass containing clear water, and if necessary to a second and a third, obtaining clean desmids eventually by a process of elimination. Of course the gelatinous secretion of desmids would in any case make perfectly clean mounts very difficult to achieve.

Mounting desmids is admittedly both a tedious and an uncertain process. I have used practically all the formulae I could find for mounting media, and however divergent the formulae, in one particular they all agreed, the chloroplasts sooner or later were distorted in shape. I quite soon formed the opinion (hetero-

dox, I fear) that to seek success by mounting a desmid in a preservative many times denser than its natural medium was a somewhat fatuous quest; also I saw no reason why desmids should be exempt from another laboratory process, that of killing and fixing. After trying several agents prescribed by the textbooks for fixing vegetable structures, I adopted Hermann's platino-aceto-osmic solution with very satisfactory results. It fixes and preserves the histological elements in an admirable manner, and at the present time there is no shrinkage or alteration of form in some mounted eighteen months ago. There is, naturally, a little alteration in colour, the chlorophyll becoming browner, but very much less so than when osmic acid itself is used. Personally, as long as the histological elements are well preserved I do not attach much importance to alteration of colour. A few drops of Hermann's solution are added to the desmids in half a watch-glass of water, and allowed to act for two or three minutes, then the desmids are transferred with a pipette to fresh water two or three times and washed, and are finally mounted in a saturated solution of thymol. This is merely distilled water which has taken up as much thymol as it will dissolve. With this fixing agent I have been able to get perfectly satisfactory mounts of *Netrium Digitus*, which appears to be a very difficult desmid to obtain well fixed, its chloroplasts becoming distorted and the cell contents contracting on the least interference with it. Hoping to avoid the tediousness of fixing and washing, with the almost inevitable loss of specimens when transferring from one watch-glass to another, for a short period I mounted the desmids straight away into $1\frac{1}{4}$-per-cent. formalin. Most of the slides then mounted became useless from one cause and another—in some species the colour bleached quite out, in other species the histological elements broke up; so I decided that formalin was useless, except perhaps for a few robust species. Ripart's solution of copper acetate and chloride, which at one time I used extensively, is another excellent fixing and preserving agent, and the colour of some species is well preserved by it. A few drops added to the desmids in half a watch-glassful of water seems to be sufficient.

So much insistence has been laid by mounters on preserving the green colour of desmids, and the formulae published for

mounting fluids so obviously have this end in view, that it was only a matter of time for my resistance to break down and commit me also to the quest of a formula that should achieve this desirable end. I have already stated my indifference to the preservation of colour so long as the cell contents remained unaltered. The colour if lost or degraded can always be simulated by interposing between the slide and radiant a green filter, which really satisfies the colour sense almost as well as having it in the desmid. At the same time it is somewhat of a *tour de force* if the colour can be retained without sacrificing essentials in cell structure. To fix and preserve histological detail in desmids is undoubtedly far easier than to preserve their colour. Chloride of gold, which is a most delicate and admirable fixative for desmids, stains the cell contents blue, but leaves them in perfect condition for study. Osmic acid by itself colours them deep brown, unless cleared by hydrogen peroxide; Hermann's solution destroys some of the blue in the green of the chlorophyll, leaving it rather yellow-green. In some species, *Closterium costatum*, *Closterium striolatum*, and others naturally somewhat yellow, the alteration in colour is negligible. The most promising results as regards combined fixing and colour preservation were got when I adopted the method of collecting already described. Desmids collected and preserved by that method nearly twelve months ago have retained their natural colour although killed and fixed. This, I am aware, is not a period of time suggestive of indefinite permanence, it is merely promising. When one has seen the colour of mounted desmids disappear utterly in about ten days, twelve months is, naturally, gratifying. I have always found *Micrasterias rotata* to be a most impossible desmid to preserve the colour of, and the only time I have approached success with it has been when collecting and preserving it on the spot. As it grows readily in a small tank I have usually a good supply of healthy individuals upon which to experiment, and have done so rather extensively. With $1\frac{1}{4}$-per-cent. formalin the colour of this species fades completely in two days, and even when mounted in such a mild preservative as thymol water the colour gradually disappears. Hence I look upon the fact of this species having kept its colour for upwards of twelve months as promising useful

results. When a large number of species from various genera are collected and preserved at the same time and in the same medium it enables one to make very useful comparisons, and I have probably learnt more with regard to colour preservation from looking over the preserved material than from numerous, and I fear somewhat empirical, experiments. The following observations on the present condition of desmids refer to material collected about nine months ago and preserved on the spot. The species of the genus Closterium keep both detail and colour remarkably well in the preserving solution already given, with the exception of *Closterium Ehrenbergii*, with which I have never been very successful; the colour is preserved excellently, but considerable contraction of the endochrome takes place. The Euastra also seem to retain their colour well. Species of Micrasterias are uncertain. *Micrasterias oscitans* preserves excellently unless the plants are aged. I have already alluded to the difficulty of fixing *Netrium Digitus* satisfactorily, and it is rather a curious fact that in the copper preservative solution the green of the chlorophyll in this species nearly always turns some shade of red. It is, however, in specimens I have collected rarely a deep-green colour, more often quite yellow-green. The filamentous genera, such as Hyalotheca, and Desmidium, preserve excellently, both colour and form. One of the species I have hitherto failed utterly with is the beautiful *Spirotaenia bispiralis*. It is quite unrecognisable a few weeks after placing it in the preservative. A fixing agent of the nature of Hermann's solution might, however, effect its preservation, but of course at the sacrifice of its delicate colour. I gathered it frequently on Dartmoor in considerable numbers, but have never come across a single specimen when looking over the material, so I conclude that the fixing agent was unsuited to it. The larger species of Cosmarium, *Cosmarium Brebissonii*, *Cosmarium Ralfsii*, *Cosmarium pyramidatum*, etc., are generally well preserved. The larger Staurastra also make good mounts, more especially *Staurastrum tumidum*. *Netrium interruptum* keeps its fine colour magnificently, then flouts one by its endochrome assuming the appearance of a pneumatic tyre with a puncture. *Tetmemorus Brebissonii* is almost invariably finely preserved, and its colour unimpaired; in fact all the species of Tetmemorus

keep well. The fine species *Xanthidium armatum* turns rather yellow-green when old cells are mounted.

On one point I have no doubt whatever, which is, that it is of very considerable importance to store the desmids in the water in which they are found growing, and I am quite prepared to admit that the colour preservation in my specimens may be due as much to this fact as to the particular preserving agent used. Bogs are usually massed with sphagnum of one species and another, and it has been stated that the sphagnol present in them is a powerful antiseptic. If this is so, and if sphagnol is soluble in water, it might be possible to dispense with a preserving agent and rely on bog water pure and simple. However, I do not advise anyone risking their material by relying altogether on the antiseptic properties of "sphagnol," as I am quite certain that the aquatic life generally captured with the desmids would have the last word. In support of the sphagnol theory, however, it is a fact that the zone of decayed matter in a bog is in a very different condition from the floor of a weed-grown pond. It is unpleasant of course to plunge into a bog over one's knees and emerge coated with brown slime, but at least one is spared the unmistakable bouquet that such an experience in a pond would entail.

The fact that some individuals in the same gathering and preservative retain their colour, while the colour of others has deteriorated, is due most likely to the age of the plant, and probably also to some pathological condition of the cell. Naturally, the most vigorous plants would be the better preserved, and it only remains when mounting to pick out those that seem to be deeper in colour than the others. This is very noticeable in *Micrasterias rotata*, where some individuals may be deep green and congested with chlorophyll granules, while others are extremely pale and semi-transparent—in other words, probably decaying plants.

The fluid in which the desmids are mounted is simply the bog water to which the preservative was added at the bog side. Usually when filling up the tubes and bottles a certain amount of the fluid is superfluous. On reaching home this supernatant clear portion in each bottle is laid under contribution to accumulate a stock solution, which is filtered and forms the mounting fluid. It will

be seen that the desmids are mounted in their own bog water, plus a small proportion of fixing agent; and if "sphagnol" is a laboratory fact they also have whatever benefit it confers. As far as the preservation of the green colour of the plant is concerned, nothing that I have tried has given me such good results, but twelve months is far too short a period to be a satisfactory test, and it may be that this method also will be merely a contribution to the melancholy collection of unreliable formulae.

One hint I may give to intending mounters of desmids which I have learned in the very practical school of experience; it is, to avoid the use of too shallow a cell for mounting them in. As a good number of species require the use of fairly high powers, there is the temptation towards the use of very shallow cells; at least this was so in my own case, and the result has been that although the cells were carefully sealed the extremely small amount of fluid has evaporated or been absorbed, and many slides made at great trouble are now finding their way to the waste box. Deeper cells containing the larger species and an appreciable amount of fluid seem exempt from this trouble.

I cannot conclude these hints on collecting and mounting desmids without allowing myself the reflection that it is unlikely that a systematic student of the Desmidiaceae will spare the time necessary for making slides of these plants. The amount of time involved in getting even fairly decent slides of the various species is very great, and it is a question if mounted specimens are of much value to the student. Specific determination of the bulk of desmids can only be satisfactorily made by studying them in three aspects, and unless a cell of considerable depth were used this could not be ensured. A former president of the Quekett Microscopical Club asserted that the best record of a desmid was obtained "by the free use of camera lucida," and I imagine that this dictum has to be accepted even now. Moreover, however attractive specimens may be which retain their life-like appearance when mounted, the fact that the cell wall cannot be adequately studied when the cell is filled with its endochrome seriously discounts the value of a mounted specimen. Identifying specimens in the genus Cosmarium is almost impossible unless the empty cell can be obtained, and the same may be said of a large number of

species in the genus Closterium. *Penium spirostriolatum* is really only interesting when the empty cell can be procured.

It may appear somewhat paradoxical, while holding the view that the interest of a mounted desmid is really very limited, that I should ask the Club to accept for its Cabinet a small collection of mounted desmids. The reason is, I hope, sufficiently obvious. Many microscopists without becoming serious students of a group are sufficiently interested in it to desire an acquaintance with its principal forms. Further, the variety of species obtainable in the collecting districts around London has no comparison with those to be got from alpine and sub-alpine situations, so that species of very considerable interest may never come in the way of the metropolitan collector unless he sees them as mounted slides. My only hope is that some measure of useful life may be granted to the small collection of slides I ask the Club to accept.

THE PRESIDENT'S ADDRESS.

SOME FACTORS OF EVOLUTION IN SPONGES.

By Arthur Dendy, D.Sc., F.R.S.
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There is, I believe, at the present day, an unfortunate tendency on the part of a certain school of biologists to underrate the importance of systematic zoology as compared with other branches of biological investigation. Professor Bateson, indeed, has expressed the opinion * that biologists in general "have abandoned systematics altogether," but our estimate of the correctness of this assertion must obviously depend upon how we choose to define the term "biologist." Some of us think that the science of biology includes the study of the whole of the organic world in all its aspects, and that the systematic description and arrangement of plants and animals constitutes an indispensable part of the foundation upon which all biological theory must be based. Indeed, I would go further, and even say that no biologist without some considerable experience of systematic zoology or botany is really competent to form a judgment on such problems as the nature and origin of species and varieties.

I have, it is true, little sympathy with the systematist whose sole object is to name his specimens and put them away on the appropriate shelves in his museum, in the hope, perhaps, of ultimately gathering together a larger collection of "species" than his neighbour. The labours of such a one, except in so far as they may afford material for the investigations of those who are better able to make use of it, hardly rise above the level of the efforts of the schoolboy who amuses himself by collecting tradesmen's labels. Such a man, indeed, has no right to call

* *Problems of Genetics*, 1913, p. 10.

himself a biologist, for his work is barren and soulless. The true systematist, on the other hand, is just as much inspired with the enthusiasm of research and the thirst for knowledge as the experimental biologist. The difference between the two lies in the fact that the experimental biologist confines his attention to the solution of certain fixed and definite problems suggested by his own very limited knowledge of the organic world, while the systematist studies the results of the infinitely varied experiments which Nature has been performing upon living organisms ever since they first appeared upon our planet. The experimenter has undoubtedly the advantage of limiting his problems so that they become more or less manageable and of performing his experiments under more or less accurately known conditions, but, on the other hand, there are many problems with which he cannot deal at all and the solution of which is no whit less important than that of the problems to which he is obliged to restrict himself. Evolution is slow, but human life is short, and slow changes may well be taking place which we have no means of detecting by means of experiment or direct observation.

Professor Sollas has estimated the time actually occupied in the evolution of the modern horse from its remote ancestor Eohippus at some five or six millions of years. During this period the horse has increased in height by 53 inches, or, allowing five years for each generation, at an average rate of 0·00005 inch per generation. This is a rate of change which, supposing it to have taken place gradually and not by a series of jumps, we could not hope to detect by direct observation of living horses, especially when we remember the fluctuations which must be occurring all the while. Nevertheless it has led to extremely important results in the course of time. The experimenter, again, could hardly hope to observe the transitions by which a normal limb-bearing lizard might pass into a limbless form such as the blind-worm. The systematist, however, knows that in both cases intermediate forms occur and is quite satisfied that, whether gradually or otherwise, the transitions have actually taken place.

There are, in short, many evolutionary problems which the experimentalist cannot touch but which the systematist may

fairly hope to solve, just as there are many with which the experimentalist alone is capable of dealing. Both branches of biological investigation are essential to satisfactory progress, and it is in large measure the failure to recognise this fact that has led to the one-sided and apparently contradictory views on the subject of evolution that are so prevalent to-day.

Take, for example, the strongly contrasted opinions of Darwin and de Vries with regard to the origin of species and, indeed, with regard to evolution in general. Darwin, as is well known, laid the chief stress upon what he called slow, successive variations, accumulating in definite directions under the influence of natural selection. De Vries, on the other hand, considers that species originate suddenly, in apparently spontaneous variations of an abrupt character, or, as he terms them, mutations.

Now it is very easy to observe the occurrence of mutations, or even to cause them to appear experimentally, as Tower has shown in the case of the potato-beetle. On the other hand it is impossible, owing to the extreme slowness with which the necessary changes take place, to demonstrate the actual transition of one species into another by slow, successive, or, as we now call them, fluctuating variations. Breeding experiments with regard to mutations give positive results, with regard to fluctuating variations they will probably give negative results, but that does not prove that fluctuating variations have played no part in evolution. We must seek other evidence on this point, and that other evidence is supplied by the labours of the systematist.

The most convincing instance of the part played by slow, successive variation in the production of new species with which I am acquainted is that of the flightless birds on oceanic islands. All zoologists are agreed that these birds are the descendants of ancestors which reached the islands in question by flying, and which must, consequently, have had well-developed wings. The loss of the power of flight can only be explained as due to the disuse and consequent degeneration of the wings, flight being no longer necessary as a means of escape from enemies. Now degeneration, resulting from disuse, appears to be a gradual process and, so far as I know, never takes place by mutation. Yet this process, continued for many generations, has resulted

in the evolution of such remarkable forms as the extinct moa, in which the wings had completely disappeared, and the surviving kiwi, in which they have become reduced to mere vestiges. This case is greatly strengthened by the fact that precisely the same result has been arrived at by many birds belonging to quite different families and in many widely separated islands. In all these instances the same causes have, as was to be expected, produced the same effect, and there is not the slightest ground for supposing that mutation has had anything to do with the matter. At the same time no zoologist would dream of maintaining that the flightless kakapo, for example, is not specifically distinct from the flying parrot from which it must have originated. We can hardly believe that such species have arisen otherwise than by slow, successive variation.

I propose to-night, however, to seek evidence from the systematic investigation of a very different group of animals.

There is perhaps no phylum in the animal kingdom that can be compared with the Sponges as regards the remarkable evolutionary series exhibited by still surviving forms. I have already dealt with one aspect of this phenomenon in a previous presidential address, in which I had something to say about the evolutionary series met with in the siliceous spicules of the Tetraxonida. You will remember that in this group all the manifold forms of spicule that occur can be derived from one and the same fundamental type—the primitive tetract, with its four rays diverging at equal angles from a common centre. By enlargement, diminution, branching, fusion, bending and so forth, of one or more of the original rays, and sometimes by complete suppression and sometimes by multiplication of rays, an endless diversity of form has been produced, and the different forms for the most part can be arranged in beautifully graduated series. The same is true, to a lesser degree, of the other group of siliceous sponges, the Hexactinellida, and also of the Calcarea, in which the spicules are composed of carbonate of lime. Again, in the case of the true horny sponges, or Euceratosa, we find a beautiful evolutionary series leading up from the simply branched, tree-like skeleton of Aplysilla to the complex reticulate skeleton of the bath sponge.

If you ask what justification we have for arranging the series as we do and for assuming that they represent actual stages in evolution, I can only reply that we have exactly the same justification as in the case of any other group of organisms. Where we find a graduated series leading from simple to complex it is difficult to account for it on any other hypothesis, especially when, as is actually the case in sponges, the various stages exhibited by one system of organs are correlated with corresponding stages exhibited by other systems. Thus in the tetraxonid sponges the evolution of spicular form is accompanied by evolution in the arrangement of the skeleton as a whole and also in the arrangement of the canal-system, and again in the Euceratosa the correlation between the degree of complexity attained by the skeleton and that attained by the canal-system is very striking. Moreover we can, in some cases, appeal to the facts of ontogeny or individual development. One of the most highly modified forms of spicule found in tetraxonid sponges is the discotriaene of the genus Discodermia. This spicule resembles nothing so much as a carpet nail, the disc being formed by three of the rays of the primitive tetract form expanded and fused together, as is shown conclusively by the fact that the young spicule passes through a stage in its development in which all three rays are separate and it is, in short, an ordinary tetract. Plenty of analogous cases could be mentioned, and many more will doubtless be brought to light as our knowledge of the subject increases.

Palaeontological evidence, unfortunately, teaches us but little with regard to the evolution of sponges, for most of the fossils known are highly specialised forms which owe their preservation to the peculiar manner in which the spicules have become united together in a coherent framework. For some unknown reason, however, it appears that most of the evolutionary stages through which recent sponges have passed are still represented by existing forms, and that is why the group is so exceptionally suitable for the study of evolutionary processes.

When we come to consider the factors involved in the production of these evolutionary series we have to note in the first place that we can distinguish between two types of modifications—

those which are obviously adaptive in character and those which seem to have no sort of relation to the requirements of the organism in which they occur. This point is very well illustrated by the form and arrangement of the spicules.

It is obvious that spicules, being secreted by the living protoplasm of mother-cells or scleroblasts, can only make their appearance in situations where such cells occur—that is to say, speaking generally, the mesogloea or middle layer of the sponge-wall. Hence, in the simplest calcareous sponges, of the genus Leucosolenia, where the entire body consists of a single thin-walled tube, we find the skeleton composed chiefly of a system of triradiate spicules lying in the middle layer of the wall, where their interlacing rays form a kind of lattice-work. In the intervals of this lattice-work lie the inhalant pores or prosopyles, and the form of the triradiate spicule is obviously related to the arrangement of these apertures in the wall of the tube, the rays being extended in the intervals between the pores and, at the same time, where necessary, becoming curved so as to follow the curvature of the wall of the tube. The arrangement of the skeleton as a whole, then, and the form of the principal spicules alike appear to be determined in the first instance by the arrangement of the canal-system and to be due to easily understood mechanical causes. Even in such simple forms as Leucosolenia, however, we usually find two further adaptive modifications of the skeleton. Some of the triradiate spicules may develop a fourth or "apical" ray, which springs from the centre of the spicule and projects into the cavity of the tube (gastral cavity), where it serves as a protection against internal parasites. A corresponding protection of the external surface is effected in a different manner, by the development of a monaxon spicule pointed at both ends, arranged so that one end projects obliquely outwards and upwards, giving a prickly or sometimes hairy character to the surface. The relations of the monaxon form to the triradiate are somewhat obscure, but we know from the researches of our late President, Professor Minchin, that the triradiate of the calcareous sponges is not a simple spicule but a spicule-system, formed by the union of three monaxons each initiated by a separate

mother-cell, and that the apical ray of the quadriradiate is another unit added to the system by yet another mother-cell. It is difficult to explain the origin of the monaxon and quadriradiate spicules, but it seems quite possible that each arose as a mutation, which, proving advantageous to the sponge, was fostered by natural selection.

If time permitted it would be easy to show you in detail how, from this simple type of skeleton, various adaptive modifications, the nature of which has been determined largely by mechanical requirements, have led up to the far more complex skeleton in each of the higher families of Calcarea, but we must content ourselves with only a few of the numerous interesting facts that recent researches have brought to light. It is clear that the arrangement of the skeleton must always be conditioned to a great extent by that of the canal-system, and, at first at any rate, the canal-system has certainly led the way. Progressive evolution has been brought about in this case by those processes of colony-formation and integration to which I referred in my last presidential address. Radial budding from the simple tubular body of a primitive Leucosolenia gives rise to the Sycon type, in which the collared cells that originally lined the whole of the gastral cavity become restricted to the radial tubes or chambers. The skeleton of the central tube becomes more or less specialised to form the gastral cortex. In the walls of the radial chambers the triradiate spicules take on a more definite orientation. One ray becomes elongated and directed towards the distal end of the chamber, and the other two tend to surround the chamber, with the angle between them facing the opening into the central cavity. The entire spicule thus becomes "sagittal," with differentiated basal and oral rays, and inasmuch as the oral rays tend to form a series of rings around the chamber the arrangement of this part of the skeleton is said to be articulate. The monaxon spicules are confined to the blind end of the chamber, where they form a projecting tuft, and as all the ends of the chambers lie at approximately the same level a new dermal surface is formed, protected by the projecting monaxons.

In the meantime the walls of adjacent radial chambers come

into contact with one another more or less throughout their length and fusion takes place. Thus the originally continuous system of interspaces between these chambers becomes broken up into more or less sharply defined intercanals, or inhalant canals, through which water gains access to the prosopyles in the chamber walls. The openings of these inhalant canals appear as gaps between the blind distal ends of the radial chambers.

The next important stage in the evolution of these sponges is the development of a dermal cortex, and it is not difficult to see how this has taken place. We find the beginning of the process in some species of Sycon, in which the external opening of each inhalant canal becomes covered over by a delicate membrane pierced by secondary inhalant pores, or dermal pores, analogous to the prosopyles in the walls of the radial chambers but quite different in their mode of origin. This dermal membrane is an entirely new development, but it has evidently been formed in a very simple manner by extension of the outer layer of the walls of the radial tubes. It is at first very thin and delicate, without any supporting skeleton of its own, and merely serves as a kind of sieve for filtering the stream of water as it enters the sponge and perhaps, by appropriate contraction of the dermal pores, as a means of regulating the rate of flow. Its appearance, however, gives rise to new possibilities in the way of skeletal development. These are realised chiefly in the appearance of a definite cortical skeleton, composed principally of triradiate spicules arranged tangentially as regards the dermal surface. The development of such a dermal cortex is characteristic of all the higher families of Calcarea.

With the appearance of both gastral and dermal cortex new mechanical principles come into play in the formation of the skeleton. Up to this point the skeleton of each radial chamber, or tubar skeleton, as it is termed, has been an independent structure developed in the walls of that chamber and in relation to that chamber alone. Now, however, that the originally separate chambers have all become intimately connected together so as to form, with the dermal and gastral cortex, a kind of secondary, and of course much thicker, wall to the central gastral

cavity, we find that further progress in skeletal development is determined by the requirements of the wall as a whole, and no longer by those of the individual radial chambers. We have here a beautiful example of integration.

In some cases the dermal and gastral cortices become, as it were, bolted together, across the intervening chamber layer, by a special system of large subdermal and subgastral spicules, whose principal rays extend in opposite directions from the dermal and gastral cortex respectively, so as to interlock with one another in the chamber layer. At the same time there is a more or less strongly marked tendency towards reduction of the articulate tubar skeleton of the individual radial chambers, which is replaced functionally by the so-called inarticulate type developed in relation to the sponge-wall as a whole.

The evolution of the inarticulate type of skeleton appears to have followed a different course in the two families Heteropiidae and Amphoriscidae. The case of the Heteropiidae is the more remarkable and forms a very curious illustration of adaptability to special requirements in both form and arrangement of the spicules concerned. We have all stages of the process represented in existing species, and there can, I think, be no doubt as to the facts of the case, which have been described by my colleague Mr. Row and myself in our paper on the Classification and Phylogeny of the Calcareous Sponges,* nor as to the interpretation of those facts at which we have arrived. Briefly stated, the sequence of events has been as follows.

In an ordinary Sycon the blind distal extremities of the radial chambers are conical in shape and, in conformity with the curvature of the wall of the chamber, the outwardly directed basal rays of the most distally situated triradiate spicules become tilted towards the apex of the cone. One of the paired oral rays now becomes directed more towards the gastral cortex, while the other grows away from the chamber-wall into the newly developed dermal membrane. With the development of a true dermal cortex the basal ray and the last-mentioned oral ray both take up their position in this cortex, lying parallel to the dermal surface, while the first-mentioned oral ray becomes

* *P.Z.S.*, September 1913.

directed vertically inwards towards the gastral cortex and increases greatly in length.

We thus have a complete reorientation of the spicule in question, and a new symmetry established as regards its rays. We have what we term a pseudosagittal spicule, superficially resembling the ordinary sagittal spicule, but in which the individual rays do not correspond as they appear to with those of the latter. The apparently unpaired and very strongly developed ray (which we may now call the centripetal ray) is one of the original paired (oral) rays, and one of the apparently paired rays (which we may now call the outer or dermal rays) is the original unpaired (basal) ray. The new symmetry never, so far as we have observed, becomes perfect, for the outer or dermal rays usually differ from one another in shape. Sometimes one is straight and the other curved, and the straight one represents the original basal ray. The centripetal ray grows much longer than the dermal rays and may even reach the gastral cortex.

In the meantime the sagittal triradiates of the chamber skeleton which lie nearest to the gastral cortex have become specialised as subgastral sagittal triradiates. This change involves little, if anything, more than increase in length of the centrifugally directed basal rays, which interlock, as already explained, with the centripetal rays of the subdermal pseudosagittals. By disappearance of the remaining spicules of the original articulate tubar skeleton the transition to the "inarticulate" type is completed.

The second way in which an "inarticulate" type of skeleton may arise is seen in the Amphoriscidae. Here the subdermal spicules are quadriradiates, the large centripetal ray being an apical ray added to an ordinary triradiate whose three facial rays lie tangentially in the dermal cortex. Obviously such a skeleton could not arise until the dermal cortex had become well established. Here, then, we have a beautiful example of convergent evolution, the same mechanical result being brought about in two totally different ways in the two families Heteropiidae and Amphoriscidae.

It is extremely interesting to observe that after the skeleton

has once been adapted in relation to the sponge-wall as a whole rather than to the individual radial chambers, the canal-system may undergo further evolution without affecting the skeleton arrangement. This is true not only of the Heteropiidae and Amphoriscidae, but also of the Grantiidae. In all these families, by a complex process of folding of the chamber-layer as a whole, sometimes accompanied by branching of the chambers themselves and reduction in their size, the radial arrangement may become lost and the well-known transition from the syconoid to the sylleibid and perhaps even the leuconoid types of canal-system be effected.

The entire series of skeletal modifications which we have so far considered are evidently of an adaptive character, suited to meet the new requirements arising in the course of the evolution of the sponge as a whole through the processes of colony-formation and integration. Many other illustrations of the same type of evolution might be selected from other groups of sponges. In this connection I may again refer very briefly to the evolution of tetraxonid siliceous spicules. In this group we never find a canal-system with elongated flagellate chambers arranged radially around a central gastral cavity, and the siliceous skeleton does not seem to have made its appearance at all until the canal-system had reached a stage corresponding to the most advanced type of arrangement met with amongst the Calcarea, with numerous small spherical chambers scattered through the thickness of the sponge-wall and a branching system of inhalant and exhalant lacunae. It has been supposed that the primitive tetraxon spicules were originally developed in the three-dimensional intervals between the chambers, just as I have suggested that the primitive triradiates of the Calcarea were developed in relation to the two-dimensional intervals between the prosopyles of a primitive Leucosolenia. However that may be, the primitive skeleton of scattered tetracts appears to have given rise along various lines of evolution to an immense variety of skeletal types both as regards spicule form and spicule arrangement. Many of these types are as clearly adaptive in character as in the Calcarea. I need only mention such cases as the development of triaenes and their specialisation for

various different purposes, such as the protection of the dermal surface by discotriaenes and the anchoring of sponges which live on a muddy bottom by means of "grapnel spicules."

As regards such adaptive modifications it really seems as if the sponge were able to do anything that may be required with the inherited material at its disposal, to convert a calthrops into a pitchfork, a grapnel or an armour plate as occasion demands.

There are, however, as I have pointed out to you before, other series of skeletal modifications which seem to have no adaptive significance whatever. These are perhaps best seen in the extraordinary forms assumed by so many of the microscleres in the Tetraxonida, all of which may be derived, through more or less complete series of known intermediates, from the primitive tetract. It is quite impossible, for example, to assign any useful purpose to those extraordinary and singularly beautiful spicules which we call chelae, so characteristic of the family Desmacidonidae. Yet these chelae exhibit such definite and constant forms, and at the same time occur under so many different modifications, that they afford some of the most useful criteria of specific distinction in this group. The reason for the existence of their divers modifications is at present a complete mystery to us; we can only say that they must be, to use a mathematical expression, functions of heritable modifications in the constitution of the protoplasm of the germ-cells, the nature of which is as yet beyond reach of investigation, and that they are perhaps correlated with other characters which are of real value to the sponge.* It seems to me probable that they originate in most, if not in all, cases as mutations, for they seem to be just the sort of characters that are known to originate in this way in other groups of the animal kingdom; but there is, I think, better evidence of the occurrence of mutations in sponges, though unfortunately it is as yet impossible to put the matter to the test of breeding experiments.

In attempting to draw up a scheme of classification, whether it be of the Calcarea or of the Tetraxonida, we find certain very

* Cf. my previous address on "By-Products of Organic Evolution," *Journ. Q.M.C.*, vol. xii. p. 65.

well marked characters appearing again and again, in a sporadic fashion, in widely separated groups, and it is impossible to arrange our material in such a way that this shall not take place. I do not, of course, refer to cases of convergence due to adaptation to similar conditions of life, which are common enough in sponges as in other animals. The characters in question are again evidently non-adaptive. Take, for example, the distribution of what are termed trichodragmata amongst the Tetraxonida. The trichodragma is a bundle of short, hair-like spicules, apparently all originating in one and the same mother-cell. They occur scattered through the soft tissues of the sponge without any relation to other structures, and it is impossible, at any rate in the present state of our knowledge, to assign to them any useful function. They sometimes occur in a whole group of evidently closely related species and have in several cases been used as the chief distinguishing character of genera. In the genus Cinachyra, on the other hand, they occur in only a single one of the twenty species recognised. They occur, again, in such widely separated families as Stellettidae, Tetillidae and Desmacidonidae, and, wherever they are met with, they exhibit an extraordinary uniformity of structure. A precisely similar phenomenon is observable in the case of the small monaxon spicules known as microxea amongst the Calcarea.

Now we know that mutations are discontinuous in their mode of origin and that the same mutation may occur again and again. Discontinuity in the present distribution of trichodragmata and microxea almost certainly implies discontinuity in origin. Probably these spicules have arisen suddenly, and on many occasions, as the result of some unknown change in the constitution of the germ-plasm. It is, no doubt, more a chemico-physical than a biological phenomenon, and that, I believe, is true of all mutations.

Let us now consider briefly some examples of what are probably to be interpreted as mutations in the case of megascleres. It is well known that derivatives of the primitive tetract not infrequently exhibit meristic variations as regards the number of their rays. It is very doubtful whether all of these can be regarded as mutations, for in many cases we find great varia-

tion in the degree of degeneration of individual rays. I have recently, however, come across a case—not, indeed, unique—in which I think the variation in the number of rays must have originated discontinuously, or in other words, by mutation One of the most characteristic spicules in the genus Tetilla is the anatriaene or grapnel spicule, a modified tetract which usually has a very long, slender shaft and three short, recurved, hook-like cladi. In *Tetilla pilula*, although the entire sponge is very small, there are probably some thousands of these grapnel spicules in a single specimen, but they are not typical grapnels, for in every case observed only a single cladus is developed, the other two have disappeared, without leaving the slightest vestige to indicate their former presence. Only three specimens of this sponge are known, but all agree in this peculiarity, the anatriaene has become an anamonaene. Another form of triaene, the protriaene or pitchfork, occurs in the same species, and these retain the full number of cladi.

In the closely related genus Cinachyra similar triaenes occur, and in a species which I have recently been investigating and shall shortly describe under the name *Cinachyra vaccinata*, three kinds are found, anatriaenes and large and small protriaenes, and all exhibit a striking peculiarity in that the apex of the shaft, which in other species tapers to a fine point, is conspicuously enlarged like a handle. I have two specimens, each containing an enormous number of these spicules, and I have seen no exception to this rule.

One more illustration must suffice. Species of the genus Esperella (Mycale) possess a somewhat varied assortment of spicules. The typical megasclere is a style, with rounded or enlarged base and evenly pointed apex. Amongst the microscleres occurs the widely distributed sigma, a C-shaped or S-shaped hook, pointed at each end. In the closely related genus Paresperella the back of the hook, just where it curves round at each end, is provided with teeth like a saw, and, curiously enough, in one of the two species which I have examined, the apex of the style is usually provided with two teeth, and in the other with one. There seems to be a correlation here between the modification of the sigma and that of the style, just as in

Cinachyra vaccinata there is a correlation between the modifications of the three kinds of triaene.

Such variations as these strongly suggest the existence of definite factors in the germ plasm, upon which the modification depends. It appears also that in some cases a factor may influence in the same kind of way the form of more than one type of spicule. On the other hand, the facts with regard to the meristic variation of the triaenes suggest that each ray may be influenced by a separate factor.

The factorial hypothesis appears to be further supported by certain very definite conclusions at which we are arriving as to the general course of evolution followed by the Tetraxonida. On the whole, evolution seems to have been progressive, accompanied by increasing complexity of structure, manifested especially in the skeleton. Along certain lines of descent, however, it appears that the culminating point has been passed and regressive evolution has taken place, resulting in simplification of structure. This simplification seems to have been effected by the complete dropping out of certain types of spicule. This is strikingly exemplified by the case of the great family Stellettidae and its derivatives. The progressive evolution of the stellettids was marked by a strong development of triaenes of various kinds, accompanied by a beautiful series of astrose microscleres, many of which have very remarkable and easily recognisable forms. In his report on the Tetractinellida of the Challenger Expedition Professor Sollas proposed the family Epipolasidae for a number of species which differ from the stellettids only in the total absence of triaenes. We know now that this group is not a natural family, but consists of a heterogeneous assemblage of stellettids which have independently lost their triaenes, and in some cases we can tell with certainty, by the characteristic form of the asters, from what particular stellettid genus an epipolasid species has been derived. We can even do more than this, for in the genus Aurora there are three perfectly distinct triaene-bearing species each with a closely corresponding epipolasid species. The genus Chondrilla, again, appears to have arisen from stellettid ancestors by loss of all the megascleres, and, finally, in Chondrosia, microscleres as well as

megascleres have disappeared, so that these sponges bear a strong superficial resemblance to the primitive skeletonless Myxospongida—an excellent example of convergent evolution.

The loss of spicules to which we have been referring cannot be looked upon as an adaptive modification, nor can we explain it as due to mechanical necessities. We know of nothing in the conditions of life to account for it, and can only suppose that it is due to some change in the germ-plasm affecting the power of the sponge to produce the particular spicules in question.

How can we reconcile these facts with the belief that evolution has taken place, in the main, by slow, successive modifications rather than by sudden mutations? The conception of factors is intimately bound up with that of mutations, and the existence of the one would seem to imply the occurrence of the other. We must remember, however, that the modifications which seem to be due to separate factors are only rarely and accidentally of value to the organism, so that they hardly ever, in themselves, lead to progressive evolution, and the fact, if it be a fact, that progressive evolution is accompanied by an increase in the number of factors in the germ-plasm is no sort of proof that the factors themselves are of primary importance in determining the course of that evolution.

If we look at the progressive evolution of the sponges as a whole we see that it has been a gradual process of increase in complexity of structure due to colony formation and integration, in which branching and budding, folding and secondary fusion, have played the chief parts, while the skeleton has constantly become adapted to suit the new mechanical requirements. If, in the course of this evolution, certain categories of spicules have been influenced, even to their disappearance, by certain factors in the germ-plasm, this does not necessarily imply that the evolution of these spicules in the first instance took place by way of mutation. A great cathedral may develop slowly and gradually for centuries under the hands of successive generations of architects and workmen, and in the end it may be destroyed in a few hours in consequence of a sudden outbreak of hostilities. Similarly the loss of characters in living organisms may be due to the appear-

ance of destructive rather than to the disappearance of constructive agents.

We find then, in sponges as in higher groups of animals, many characters that are obviously adaptive and many others that appear to have no such significance, and characters of both categories are used by systematists as indices of genetic affinity, for the purpose of constructing a natural, phylogenetic arrangement of the organisms in question.

As to which set of characters is to be regarded as the more important from the point of view of the student of progressive evolution there can, I think, be little doubt, but how far the division into adaptive and non-adaptive corresponds to the distinction between fluctuating variation and mutation is a different question. Certainly the chances are greatly against a mutation, when it first appears, having any adaptive significance. The apical ray of a calcareous quadriradiate may perhaps arise as a mutation, at any rate there seems to be no mechanical necessity for its appearance. It may remain quite short and without obvious significance for the well-being of the sponge, as in the dermal quadriradiates of some species of Leucetta, but, in other cases, it may be seized upon, so to speak, as a new weapon in the struggle for existence and used as one of the most important constituents of the skeleton, as in the Amphoriscidae. Many of the specific characters of the microscleres, again, may have arisen as mutations, but they seem to have remained entirely meaningless from the point of view of function.

It seems to me incredible that the long series of adaptive changes which have taken place in the evolution, say, of the skeleton of the higher Calcarea, and which are so closely correlated with one another and with the evolution of the canal-system, can have been entirely or even mainly dependent upon the accidental occurrence of mutations, which are supposed to take place in all directions and without any relation to the necessities of the organism. When, for example, the dermal cortex appeared no doubt scleroblasts wandered into it as is their wont, and there gave rise to triradiate spicule-systems tangentially arranged. The whole process is obviously determined chiefly by mechanical conditions. The establishment of one modification gives oppor-

tunity for the occurrence of another, and there is no reason to suppose that mutation has had anything to do with it beyond occasionally and accidentally providing the organism with some new character capable of being developed into something of value.

In my opinion the slow, successive variations of the Darwinian theory have had far more to do with the evolution of sponges than the process of mutation, and are mainly responsible, under the guidance of natural selection, for adaptive modifications.

This is perhaps nowhere better seen than in the root-tufts of anchoring spicules so characteristic of those species of Tetillidae that live on muddy sea-bottoms. The starting-point for the development of such a root-tuft is, of course, provided by the anatriaenes or grapnel-spicules, whose distal ends, bearing the three recurved hooks, frequently project beyond the surface of the sponge. The only thing necessary for the development of an efficient anchoring tuft is the elongation of the shafts of those anatriaenes which project from the lower part of the sponge, and such elongation is exactly what might be expected to take place as the result of fluctuating variation under the influence of natural selection. Exactly the same kind of thing is seen in those curious Trichostemma- and Crinorhiza-forms which support themselves, parachute-like, on soft ooze by throwing out a fringe of long spicules or spicule-bundles, radially arranged, like the ribs of an umbrella. If the intermediate forms happen to disappear, such characters as these may of course be used by the systematist for the discrimination of species just as well as characters that are supposed to arise by mutation.

In my Presidential Address to the Zoological Section of the British Association for the Advancement of Science, at the Australian meeting in 1914, I had occasion to observe that "it seems likely that mutation has had a great deal to do with the origin of species, though it may have had very little to do with progressive evolution." My friend Dr. Dixie, in a recent article in the *Church Quarterly Review*, seems to regard this statement as indicative of inconsistency on my part, as I had previously admitted that mutation might be one of the factors of divergent

evolution. He suggests that I should "perhaps seek to reconcile the statements by insisting on the distinction between 'divergent' and 'progressive' evolution." Certainly no such idea of reconciliation was in my mind. I thought I had made my position clear in the succeeding paragraph, in which I remarked that "just as we have learnt to regard individuals as the temporary offspring of a continuous stream of germ-plasm, so we must regard species as the somewhat more permanent but nevertheless temporary offshoots of a continuous line of progressive evolution."

As I have evidently not succeeded in my intention, I may perhaps be allowed to make a fresh endeavour to relieve myself of the charge of inconsistency, and to illustrate my meaning once more from the great storehouse of facts derived from the study of sponges. A very large number of species in this group are, as I have already indicated, distinguished from one another by minute but constant differences in the form of the spicules, especially of the microscleres, which have no conceivable value from the point of view of adaptation and have in all probability arisen as mutations. Such specific characters may be afforded by the number and form of the teeth on a chela, or by the ornamentation of some other form of microsclere, which can only be made out under high powers of the microscope. Characters, on the other hand, which are obviously adaptive in nature, such as the arrangement of the skeleton as a whole and its relation to the canal-system, which seem to have developed, if not to have originated, by slow, successive variation under the influence of natural selection, are usually common to many species in the same genus; they are not, as a rule, specific characters. Hence, though species seem frequently to have arisen as mutations in trivial and non-adaptive characters, evolution on the whole seems to have taken place by a process of progressive evolution, in which mutation has played a comparatively small, though by no means negligible part. In the vast majority of cases a specific character appears to bear much the same relation to the organism that exhibits it as the colour of a motor-car bears to the car itself. The colour has nothing to do with the efficiency of the car, and plays no part in the evolution of motor-cars, but it affords a very convenient means of distinguishing one car from

another. If all cars of the same kind were painted of the same colour the analogy would of course be more complete.

In conclusion, if any one should ask me how I should propose to define the term "species" as applied to sponges, I could only reply that, at any rate in the present state of our knowledge, no satisfactory definition is possible. In practice we give the name to any group of individuals that closely resemble one another and are at the same time distinguishable from any other group by one or more characters that they possess in common. Such groups may have arisen in divers ways, as by sudden mutation or by the dying out of connecting links in the course of gradual divergent evolution, and it is quite possible that hybridisation has also played a part. It is more than probable that many groups now regarded as distinct species will ultimately be found to be connected by more or less perfectly graduated series of intermediate forms. This probability, however, has no terrors for the philosophical systematist, for one of his principal objects is to reconstruct the phylogenetic tree and demonstrate the genetic relationships of all the members of the group on which he works, and from this point of view the more connecting links he discovers the better he will be pleased. Whether his species are good, bad, or indifferent, is a matter of secondary importance, though of course every reasonable worker will avoid as far as possible the unnecessary multiplication of specific names.

ON THE BDELLOID ROTIFERA OF SOUTH AFRICA.

PART I.

By W. Milne, M.A., B.Sc., F.R.S.E.

(*Read March 28th,* 1916.)

Plates 2–6.

The material for this paper has been gathered intermittently during the last ten years. A few of the species described are aquatic, but the large majority are moss-dwellers. The aquatic species are probably very numerous in South Africa, but little attention was paid to them.

Only a few meagre lists of South African *Bdelloida*, with no description of new species, had been published when in 1911 Murray's *Bdelloid Rotifera of South Africa* (11) * was issued. He mentioned fifty-three species as having been found, and tabulated forty which he had himself seen. Of these forty I have seen all but seven, and of the other thirteen I have seen ten.

I have been enabled to widen the scope of this paper by the help of several friends, who provided moss from parts inaccessible to me, and I have much pleasure in naming species after them.

I have had much correspondence with Mr. Bryce, and feel greatly indebted to him for assistance freely given. I received also from Mr. James Murray many helpful suggestions.

Mr. Bryce (6) has done a great service to students of *Bdelloida* in publishing his new classification. He has brought order out of what was fast becoming chaos. His classification is an excellent piece of work. I have only one small objection to make, and that is to a name. Mr. Bryce has proved conclusively that *C. elegans* (Ehr.) was certainly different from the short-footed species, which have usually been termed *Callidina*, therefore it follows that the genus *Callidina*, founded on that species, cannot include the short-footed ones. At one time I

* *Note.*—The figures in brackets refer to the Bibliography.

(2) thought *C. elegans* (Ehr.) was really *Adineta*. That is probably a mistake. At any rate I was satisfied that *Callidina* (Ehr.) could not include the short-footed species, and so I constituted a genus, *Macrotrachela*, for them. Ehrenberg's genus is not necessarily done away with.

The definition for *Macrotrachela* first given still applies, with an addition rendered necessary owing to Mr. Bryce's removal of the pellet-makers into a new genus—a thoroughly sound proceeding—*Macrotrachela* :—*Bdelloida* having three toes; foot shorter than the pre-intestinal part; oviparous; and not pellet-makers.

I shall in this paper, therefore, place all species which answer to this definition under the above genus.

Harring (12) has taken the same view with regard to the name of the genus.

The genus *Habrotrocha* is growing into a very large and unwieldy group, so I have taken this opportunity to separate some, and place them in a new genus, *Otostephanos*. They are different from all the others in that they possess a ring of fair thickness round the corona, with short breaks ventrally and dorsally. Murray's *H. auriculata* (10) which I have known for several years, is one of them. I have three other species to describe.

In the description of species I generally mention the nature of the lamella. Some writers consider that there are two separate lamellae, at least in some species. I have never been able to make out more than one. There are several undoubted instances of a single hood-like lamella, without any indentation whatever, as in *H. cucullata* (Murray). The common form has a sharp fold in the middle of the lamella, giving it a double appearance, but not with two separate parts. There are some which seem to me to have a double fold, giving in certain positions a triple lamella, as in *P. grandis*; and others with a triple fold giving a quadruple lamella, as in *M. russeola* and *M. Ehrenbergi*. The ear processes mentioned by Janson (3) as part of the rostral sheath in the latter, are part of the lamella.

I have made some general remarks on the jaws of *Philodina*, which will be found under the description of *Monoceros falcatus*.

In 1906 my attention was drawn to a small animal, chiefly through the odd appearance of a bunch of large appendages,

posteriorly. It was soon apparent that there were other abnormalities about the creature, and that it was so aberrant—although an undoubted Bdelloid—that it could not be placed in any of the three families as given in Bryce's classification of the *Bdelloida* I have therefore constituted a new family for this animal :

MONOCEROTIDAE fam. nov.,

Bdelloida having, on the penultimate segment of the foot, one spur only.

The MONOCEROTIDAE differ from all other known *Bdelloida* in possessing only one spur. That they are Bdelloids, I think there can be no doubt. In their habits they resemble MICRODINIDAE and ADINETIDAE, but on the whole come nearest to MICRODINIDAE ; but the differences are very great. The jaws in each are abnormal, but not of the same type. The corona is very meagre in MONOCEROTIDAE, but wanting altogether in MICRODINIDAE. Both possess four toes, but in MONOCEROTIDAE the toes have each a separate external sheath.

In all other details, not already referred to, there seems to be no great difference from *Bdelloida* in general.

MONOCEROS gen. nov. *

Generic Characters.—Having one spur only ; four toes, and a fully developed rostrum. The corona is inconspicuous or obscure. Jaws are abnormal.

Two small circular arrangements, with not the slightest semblance of pedicels, situated on a prone face, represent the corona in *Philodina*. The gullet is extremely short.

Monoceros falcatus sp. nov.

Pl. 2, figs. 1–1*d*.

Specific Characters.—Rostrum well developed, with strong cilia. Corona inconspicuous—a sessile rotulate arrangement bearing rather feeble cilia on the rims and possibly no cilia

* Since the above was in type I have learned that the generic name Monoceros is already pre-occupied and according to the rules of nomenclature is ineligible; this also applies to the ordinal name as well. It is intended to rectify the error in Part II of this paper.

posteriorly. Gullet extremely short. Jaws quite abnormal. A short tube from the mastax, dorsally, leads into a large stomach mass. The foot is very stout, and tapers very little—possibly of four segments. Toes four, sickle-shaped, exceptionally long, each in its own large sheath. One large spur, dorsally placed; broad at the base, curving outwards slightly and then inwards to a point.

Antenna about as broad as long—with scrubby setae. There is a large brain mass, situated above and behind the mastax, branching off anteriorly into the antenna and forward, apparently into the rostrum. Intestine large, and contractile vesicle not very conspicuous. Foot glands are large. Size, 1/120th inch.

Monoceros falcatus is quite small and of a pale glaucous colour. The most striking feature is the posterior of the foot, with its four great sickle-shaped toes and the large spur; looking, when all planted downwards, as if supported on a banana-like bunch of props. I should probably have overlooked the first specimen had it not been for this odd appearance. The extended toes and the spur are not unlike each other, and at first I thought there were three spurs and two toes. They look altogether too big for the animal, and give it a far from graceful appearance. The spur and the extended toe are of about the same length, and equal to about one-eighth of the out-stretched animal. When feeding in the open, it may be seen with all four toes extended and planted on the glass; it has then a very peculiar appearance, as if resting on four props or stilts; and stranger still is the appearance when it uses the spur as a fifth prop. It occasionally may be seen balanced on the spur alone, but very rarely are the toes all withdrawn at the same time; two is the commonest number extended, and these the two next the spur. The tip of the toe is very small, and when it is withdrawn the sheath invaginates to about half its length, when it reminds one of a cylindrical bag, or a suspended knickerbocker leg, slightly longer than broad. It is a rather grotesque sight to see the four great cylindrical bags pendant alongside each other. The toe tips may usually be seen peeping out in the middle. Occasionally a toe may be shot out with great force. The toe muscles are exceedingly strong, and when extended the whole is very taut and rigid. Each toe has its own sheath, and can act independently of the others. When exserted, the toes are planted well apart, and can be seen projecting outside

the body width, and the tips form the corners of a figure, almost a square. The convex bend of each sickle is outside, and the inner concaves face each other diagonally. The spur is of elliptical form, and is motile at the base, at least it can be bent downwards.

The rostrum is of the usual Philodine type, and is short and stout. It has a double frontlet, and bears long cilia, which are more powerful than those of the corona. It is capable of taking an extremely firm hold. When the animal is feeding, the rostrum is not tossed over.

The corona might be looked on as decadent, with the whole—wheels and pedicels—reduced to thin discs; or—what is much more probable—as rudimentary, and advanced half-way in the evolution of a corona of the *Philodina*-type, from a prone face of the *Diglena*-type.

On the ventral face of the post-rostral segment, is seen a double rotulate arrangement, somewhat like two thin discs inset in the surface, and barely rising above it. These project very slightly, right and left, over the segment, and probably bend slightly towards each other. There is a narrow space or alley between. Along the rims of these discs, cilia are borne up the centre and round towards the posterior, where the discs are not well defined and the cilia are not visible. Just here—at the back of the wheels—the body depth increases in the ventral direction, and, projecting almost over the posterior of the discs, prevents a clear view of the back of them. This high boundary determines the oral entrance, into which the alley between the discs leads. This alley, down which the current streams, would thus be analogous to the sulcus in *Philodina*.

The gullet is extremely short, as the jaws come almost to the orifice, but do not project. There is a short oesophagus, similar to that seen in some species of Ploima between the mastax and the stomach.

M. falcatus is closely plicate, and many samples are so wrinkled and reticulated that the optical difficulties are increased to such an extent as to make it almost impossible to see the internal parts. These wrinkled specimens are usually seen after the water has been kept for a day or so. Seldom are live specimens found after the second day in the bottles, even when the water has been aerated periodically. This, taken with the fact that

their habitat is in rushing water, seems to indicate that a plentiful supply of oxygen is necessary.

The shape is variable; even when creeping it may keep the trunk fairly stout, or may attenuate it to a very considerable degree.

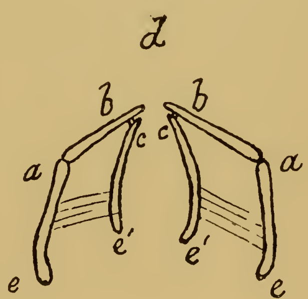
M. falcatus has two methods of progression. It has the ordinary leech-like manner of creeping, when it takes a very firm hold with the rostrum, draws up and plants the foot with a rabbit-like hop, and then shoots forward the head again. Its speed is by no means great, and in the open it usually takes but one or two hops at a time, then squatting on two, or it may be four toes, it keeps on swaying the head only, up and down and all round in a restless way, with the cilia of the corona and rostrum vibrating energetically, and the jaws in motion. It can also proceed by swimming, but in a rather helpless rolling sort of way. It aids the effect of the cilia by contractions of the body, and even then the motion is little more than visible. In its habitat, where the water flows swiftly, its power of swimming would be practically useless to it when dislodged from the moss.

It seems to be most at home when creeping about in the moss. It hops from branch to branch, the head searching tirelessly all about. Every now and then the rostrum is pushed hard against the moss, when with a decided snap it may be successful in breaking off some particles; it then bends the rostrum down over the corona, and thus with the aid of the cilia, which vibrate furiously, guides the food towards the oral entrance. Frequently when exploring the moss, it jerks back its head at the most unexpected times, a most irritating habit, which also characterises the Adinetae, whose manner of feeding is somewhat similar. It is a great gymnast and seems to enjoy itself most thoroughly when, attached by perhaps two toes high up on the rubbish, it happens to throw its head and body out into the open. It squirms and contorts itself into most fantastic shapes, without the least impression on the foothold. The muscles of the toes and the robust foot are so powerful that it can maintain itself for any length of time, straight out and tense—with no support but the toes—notwithstanding the extraordinary contortions of neck and trunk indulged in; and quivering all the while with excitement and pure pleasure. At times it sways round with the toes as a pivot, and without the slightest sagging in the general

horizontal direction. Without losing its hold, it may even bend its body quite round on itself, and search with the rostrum along the moss and rubbish to which the toes are attached, scraping off particles as already described. It can search in this way, without once shifting its hold, a circle of which its body is the radius—a provision of great service to it, as it lessens the chances of its being swept away by the swift current in which it lives.

There are the usual telescopic joints on the foot and neck, and though these slip out and in at times, I do not remember ever having seen one contracted into a ball. Dead specimens are always fully extended, with two toes showing the sickle shape, and two contracted into their sheaths.

The jaws at a first glance seem to be of the nature of some of the Ploima, but are quite different. They are in two parts (right and left) exactly alike, without any connecting single fulcrum. The mallei are of the simplest, consisting of two rods jointed together, both mallei being in the same plane. In the normal jaws nearest in general appearance, *e.g. Albertia*, the central rami and fulcrum are united together and form one part. In *M. falcatus*, however, the fulcrum has been, as it were, cut in two. There are thus two exactly similar portions (right and left) quite separate from each other, and accordingly different from any arrangement obtaining among the Ploima. Each fulcrum has become an exceedingly short and minute rod, visible only under very favourable circumstances. It is transposed to the anterior and lies between the uncus and ramus ends, articulated or muscularly attached to each. There is evidently a glassy plate connecting *ae* and *ce*[1], for in some of the larger examples several fine striae were seen between, thus indicating a link with the *Philodina* jaws.



The jaws seem to have two actions: a blinking, pecking action, somewhat like that of some of the Notommata; and a slightly rotating one, a little approaching that of *Philodina*, but jerky instead of the even, steady motion of the latter.

The nibbling, pecking action would be produced by the shooting forward of the two halves towards *d*, without any rotation or alteration of the direction of the planes *a c e* e^1; and then reversing the action. The rod *ab* has considerable freedom at the point *b*.

The second action seems to be produced in something like the following way. When the rods *ae* are pushed inwards and downwards, the rami ce^1 will bear on each other at the top ends, and as the pushing is continued will rise upward and forward—*a c e* e^1 being rigid planes—and *b* will be shot forward towards *d*; the whole action producing a grinding, rotating and forward movement at the front of *c* e^1. The point *e* in the above action apparently approaches e^1 but does not in reality, for as *e* goes down e^1 rises, giving the rotating movement which would not be possible if the planes *a c e* e^1 were not rigid.

When the reverse movement takes place, *b*, *b* may be brought down as far as to bring the unci in a straight line, throwing particles that may have been caught on to the grinding surfaces of the front ends of the rami and possible parts of contact below.

It seems to me that there are here all the elements of the *Philodina* jaws. The two halves of the jaws of *M. falcatus* represent the framework of the *Philodina* subquadrate parts; all the evolution required would be a thickened margin to the glassy plate between, and soldered on to *e* and e^1; the joints in the mallei soldered; the rami and unci points muscularly connected; and the minute rods thrust under, and thus taking the position of the double fulcrum in the *Philodina* jaws.

In the *Philodina* jaws the only parts soldered together at the front and back of each half are the borders of the surface which carries the teeth, they at least appear so. The ends of the rami are only muscularly attached. I can find nothing at all that could be considered a fulcrum where Gosse (1) represents it to be. The fulcrum of PLOIMA is represented here by two chisel-faced teeth (Pl. 3, fig. 3*e*) opposing each other, one on the keel of each ramus about one-third back from the anterior. Strong muscles connect them with the front of the jaws. The outside borders of the surfaces carrying the teeth and the striae are the mallei, and the inside opposing faces, each of which appears somewhat like a triangular file in shape, represent the rami. Round the jaws are three great muscular masses, two from the front

round the shoulders and backwards, and one from behind and under. I have seen what I took to be a muscle attached to the bottom mass and branching upwards into two which are fixed, one each, to the posterior ends of the rami. When the jaws begin to act, the first motion is usually a downward one in the centre. This would be caused by the pulling of the branching muscle referred to. As the pulling is continued, the chisel-faced teeth are ground against each other and downwards, and throw up the mallei. Then the muscles from the shoulder muscular masses act, and pull the mallei down; the chisel-faced teeth oppose each other at their lowest points, and throw the inside faces of the jaws (rami) up and away from each other with a slight rotation, as the front ends of the jaws are muscularly connected while the posterior ends are free. The jaws separate so far in *P. grandis* that when open the chisel-faced teeth can be seen between them from above. In each up-and-down motion the shock can be observed, just when the full pressure comes to bear on the opposing chisel faces. The resulting slight rock on the point of pressure can be seen.

The position of *Monoceros falcatus* seems to be somewhere between Ploima and *Philodina*. There are features which seem to show that it might very well have been evolved from free-swimming ancestors among the Ploima. The jaws, corona and spur might have come from some tailed form of *Pleurotrocha*. Probably there were parallel roads attempted from Ploima to *Philodina*. *M. falcatus* on one of these failed to get all the way, and *Microdina paradoxa* also failed on another road.

One is tempted, at this stage, to look for signs, among the *Bdelloida*, of any links towards other branches of the Rotifera. There are the horn-like processes of the corona of *Ceratotrocha cornigera*, which might point the way to the Floscularia, possibly the farthest advanced of the Rotifera, as one of them, *F. moseli* (5), has rudimentary kidneys and is thus probably the highest of all.

Habitat.—Not far from Algoa Bay, to the west along the coast, are the grass-covered Cape flats. Walking across these flats near the farm of Draaifontein, one suddenly comes on a narrow, deep ravine, whose existence was quite unsuggested by the flat surroundings. On descending to the bottom, through the scrub and trees, a little stream is found, whose banks are covered

with maidenhair and other ferns. The ravine is not long, and meets with another larger one at right angles. Within a few feet of the junction, a large rock crosses the bed of the smaller ravine, and slopes steeply down stream. Over this declivity, which is covered with moss, the water glides swiftly. On this moss-covered slope is the home of *Monoceros falcatus*, and there it literally swarms. For several years I found it there without fail; then for two or three years I thought it had disappeared, as I could not find a single specimen in the moss brought to me from the ravine. It then occurred to me that the waterfall had been missed, so on the next opportunity I had the moss taken from the rock, and sure enough the animal was again found in abundance. It seems that it requires swiftly flowing water to thrive, at any rate this rock was the only place where I found it flourishing.

Family Philodinidae.

DIDYMODACTYLOS gen. nov.

Generic Characters.—Bdelloida, having two toes only.

Didymodactylos carnosus sp. nov.

Pl. 2, figs. 2–2*c*.

Specific Characters.—Large and massive; corona one-half wider than collar. Antenna very short; no eye-spot. Investment of stomach yellowish. Foot very short, of four segments. Spurs short, straight cones rising out of great globular or spherical bases without interspace. Toes, two. Teeth, four or five. Size, 1/50th inch.

This is a handsome animal, so Philodina-looking that I took it for one without suspicion, until I caught sight of the toes, and became aware that it had only two, distinct and well developed, and with no signs of any reduction. They are extruded from a narrow rectangular orifice, and can be seen extending through the sheath (Pl. 2, fig. 2*b*). In 1886 (2) I pointed out that the number of toes formed a very natural means of generic distinction; and as that method has been utilised by Bryce in his classification, it followed that a new genus was rendered necessary for this animal.

The corona is very wide and attractive, and equal to about one-fourth of the length of the animal when creeping and fully ex-

tended. It is one-half wider than the collar and twice as wide as the neck. The sulcus width is about three-fourths that of each disc, and is fully occupied by the boldly outlined and characteristic upper lip, consisting of two fine lobes and an intervening part with a boldly notched anterior border. It is rather difficult to get a good view of the corona, as the head is kept moving ceaselessly when feeding. Even when creeping, it has a restless, jerky, fussy manner. Though it does not get over the ground very fast, it is very forceful, and brushes its way under and through the rubbish with great vigour.

The rostrum is stout and fairly long, and has a triple arrangement of the lamella. There is a well-marked rosette round the closed mouth. The antenna is a mere stump, about one-sixth of the neck width. There are no eye-spots on the rather large brain mass.

The jaws are relatively small, and are crossed by four or five teeth of no great size. There is great difficulty in making quite sure of the number of teeth, on account of the restless habits of the animal and the density of the integument and parts overlying the dental bulb. There is a large gland below the mastax, darker in colour and finely granulated. The lumen is narrow and has a yellow investment. The intestine is large, and the contractile vesicle small and of short period.

The rump is well marked off from the trunk and is heavy. The foot is cleanly modelled, very short and equal to about one-twelfth of the total length. The second and third segments are each very short. The foot glands are very heavy and extend well up through the anal segment. The spurs are very distinctive and handsome; the great globular bases are quite unique, and the short cones seem set into them.

The foot and trunk are delicately and closely stippled.

The only Bdelloid nearly related to this is *Mniobia tetraodon*. In some points there is a considerable resemblance between the two. The samples of *M. tetraodon* which I have seen agree with those found by Bryce in the upper lip and size, but are more in accord with Janson's account (3) in the spread of the corona. I find cases of corona to collar as 15 : 14. In some the proportion was slightly greater, but none showed so great a proportion as Bryce mentions. The upper lip in mine agrees with Bryce's description (4). The upper lips in the two species are not very

different and each has a very short antenna. *D. carnosus* has a wider spread of corona, a more opaque integument, and is more massive, more especially towards the rump. It has four segments in the foot, while *M. tetraodon* has three as stated by Janson. The bases of the spurs in *M. tetraodon* are not globose but irregularly swollen, seen best ventrally towards the middle, and are relatively smaller. The spurs of *M. tetraodon* are curved and longer. In *D. carnosus* the two toes are distinct (fig. 2*c*); in *M. tetraodon* there is but a suggestion of two toes, caused by a slight pinch on one side, but the two parts on either side of this pinch never alter their relative positions towards each other, when exserted, which they would do if there were two toes. *D. carnosus* is of a much livelier disposition. *M. tetraodon* would seem to be a divergence from *D. carnosus* or some common ancestor.

Habitat.—Ground moss found growing very sparsely in grass at Springfield near the river, Uitenhage district. It was exposed to the broiling sun, and subject to long droughts. Very rare.

Genus PHILODINA (Ehr.).

Philodina praelonga sp. nov.

Pl. 4, figs. 5–5*b*.

Specific Characters.—Of a fairly deep yellow colour, tinged with red in the alimentary tract. Long and narrow; the rump and foot taper gradually from the end of the trunk, which is almost uniform in width. Corona is very wide relative to the body; about one-half wider than the collar, and more than one-fourth of the animal when creeping. Antenna is equal to nearly three-fourths neck width. Two lemon-coloured eye-spots on a small brain mass. Jaws not large, squarish; teeth, three large and one small. Foot has four segments. Spurs short, practically parallel, with short, straight interspace. Toes, four; two front ones stout and long, the other two quite small. Size, 1/50th inch.

This is a long, narrow animal which does not broaden out anywhere when creeping, and very little when feeding. It creeps with a sort of dead pull and progresses rather slowly. It swims very freely, as might be expected, seeing its home is in pools. The corona is most elegant and attractive, and is very wide-spreading. Corona, collar and neck are to each other as 35, 25 and 15, and in some cases the corona is as much as one-half wider than the

collar. The wheels are very shallow and practically circular in shape, and the rims bearing the cilia form complete circles except for the gap over the sulcus, which is very small owing to the slight depth (dorsal to ventral) of the sulcus. The sulcus (right to left) is wide and the bottom boundary of it is a sharp, thin ridge.

When the animal is feeding, the head is placidly swayed up and down and round about, each great wheel with its vibrant cilia flashing out brilliantly, in varying shades of yellow, as the incidence of the light changes; now a circle, now some form of an ellipse. The effect is heightened by the lifting or screwing up, at times, of the outside boundaries of the wheels farthest from the sulcus, bringing them more towards the position facing each other, and foreshortening the view of the wheel. The cilia flash in great waves, and the whole effect is most striking and beautiful. When viewed from above, the discs give almost the best representation of two revolving wheels of any species.

Slight prominences on each disc bear two long setae. On account of the shallowness of the corona, the borders of the upper lip are very flat. The lateral borders have to rise very little from the collar to reach above the sulcus bridge. There they bend round at sharp angles between which the anterior border sags a little, so as to be slightly concave. The sulcus ridge, with its ends elbowing up into the discs, often shows over the upper lip, almost parallel.

Brushes of scrubby setae protrude from the long antenna. Two eye-spots, very distinct, are seated on the brain mass, which is of an inverted pear shape, well defined, but very small for such a large animal. Jaws of medium size, and rather square in outline, show on each side three large and clearly defined teeth and one smaller, not greatly larger than the striae, but whose point can be distinctly made out. Jaws and borders are often stained deep yellow.

The rostrum is stout and has a double lamella. From the posterior of the rostrum back to the end of the trunk, the width is practically uniform when creeping; there is just a gentle inward curve between the antenna and mastax. No swelling is visible in the lumbar region, its outline tapers gently into the foot, and this tapering is continued down to the spurs. At the ankle there is a slight sudden narrowing. The outside edges of the spurs

are practically parallel—the width at the ankle being 4·5, and across the spur points 5. A straight interspace, nearly half the width of the spur base, separates the short spurs, which are rather less in length than the width of the ankle. For a very short distance from the interspace, the inner border of the spur proceeds parallel to the outside edge, and then diverges straight to the apex. I have frequently seen the spurs clipped together in an inward direction, but have never observed the points farther apart than the normal. The spur segment is continued well back from the spurs to the toes. Very noticeable is the difference in size of the toes (fig. 5*b*), the front ones having at least twice the diameter of the back ones, and being much longer. About the middle of the toes, the diameter is greatest, and from there they narrow slightly to the extremities, which are terminated by peculiar cylindrical brushes. Muscular threads proceeding upwards from the toes are seen very distinctly.

The trunk is widely plicate.

Young specimens have seldom any yellow colour.

P. praelonga can be kept for a considerable time in the bottles, provided the water is renewed frequently; and the eggs hatch out. They do not seem to remain long healthy in an ordinary slide.

Habitat.—Draaifontein farm ravine, along with *M. falcatus*; also abundant in some of the pools in the larger ravine below.

Philodina grandis sp. nov.

Pl. 3, figs. 3–3*g*.

Specific Characters.—Body long and stout; bright yellow in trunk, but paler towards extremities. Corona very large and widespread, equal to well over one-fourth of the fully extended animal. The sulcus is nearly as wide as the disc. A stout peg on each wheel carries at least three setae. Rostrum stout, with trifid lamella. Antenna long and stout, equal to one-half of neck width. Jaws very large, heart-shaped with four very large teeth and one smaller. There are no eye-spots. Foot is long and fairly stout. Spurs narrow and equal to width of ankle, with narrow convex interspace. Two of the toes are very large. Trunk and rump are very closely stippled. Size, 1/50th inch with frequent samples up to 1/40th inch.

This is the species of Philodina referred to by Murray (10), who gave some figures of it. The colour is sometimes light lemon, but usually is bright yellow in the trunk. The ovary frequently shows a red tinge. It is a very large and powerful animal, one of the largest of the moss-dwelling species; and though not very much longer than *P. praelonga*, is much more massive. It quite rivals *M. russeola*, but is not quite so heavy in the rump and foot. It creeps very steadily with long strides, planting the toes well up under the head, and without any jerky action. When feeding, it keeps on ceaselessly swaying the head round about, and up and down, in a very lazy sort of way, so that the focus is being continually slowly altered.

The corona is of very great size—up to 1/135th inch in the largest examples—it is larger, and even more striking and handsome than that of *P. praelonga*, with equally circular discs. On account of its wheels being so round and wide, and the ciliated rims standing out so clear of the pedicels, there is presented the most perfect illusion, in any rotifer, of two cog wheels in motion. There seem to be about fifteen cogs or triangular bunches of cilia on each wheel. Some friends, on being shown the wheels, could hardly be persuaded that there was no rotation. The corona, collar and neck are to each other in the proportions 45, 30 and 20.

On each wheel is a stout peg bearing a bunch of, at least, three long setae. On the ventral side of the sulcus, just between the pedicels, there is a ridge or membrane with a deep gap, which evidently exercises a selective action on the particles streaming past. The sulcus is nearly as wide as the disc, but the discs lie so close on to the sulcus that the great cilia play in and round it in such a way as to interfere almost completely with a view of the borders of the upper lip, and to make the sulcus look narrower than it really is.

The pedicels move independently of each other; one wheel may be seen being twisted round or bent over, while the other retains its position. Both wheels may be turned over in the one direction, till they appear to revolve in parallel planes. Sometimes they are pushed towards each other till the straight front margin of the upper lip becomes a deep serrated V. A very common position is with the extreme ends of the corona bent, symmetrically, well down.

At the first glance the upper lip seems a very simple one, but to

realise all its intricacies takes a prolonged inspection, aided by a good deal of luck in getting the animal to turn its wheels in particular directions, so that views may be had under the great cilia which lash down into the sulcus, especially just under the dorsal termini of the primary and secondary wreaths. When the head is in the usual position it is practically impossible to see the corners under these termini.

The secondary wreath is well developed, and passes round, laterally, on a considerable projection which is continued lower down towards the neck. The lower boundary of the latter projection continues round dorsally (still standing out) to the sulcus in a wavy curve, and just under the end of the secondary wreath, bends down and round in a tongue-like part (Pl. 3, fig. 3*g*), and is continued in a large scalloped curve *s* round and up to near the corner of the upper lip. All round the lower rim of this projection, the tongue part, and the scalloped curve, is a narrow, glaucous, fleshy-looking band. This cannot be considered part of the upper lip, I think, as it does not start from what is usually considered the collar. Just below the lateral projection is the collar, and from it there proceeds a band *r* (placed lower in the figure than its real position to show more clearly), usually shadowed or covered by the projection above. When the wheel is screwed up and forward, the band can be traced up to the middle of the tongue part *t* already mentioned. There it seems to stop, but as it looks to be at a lower level, it evidently passes under. From the front corner of the upper lip there passes back a thin fleshy border—highest in the middle—down close to the other side of the tongue part. This is apparently continuous with the band already traced to the under side, but a good view is very rarely had owing to the play of the coronal cilia, and even at the best is not quite free of interference. This band, then, which apparently passes under the tongue part, is evidently the border of the upper lip, whose front margin is nearly as wide as the sulcus, and practically straight.

There is another line which starts from the collar alongside the first, and half-way towards the sulcus begins to widen out into a broad band *u*, which passes close to, and is often in contact with, the tongue part, and then bends across immediately in front of the rostrum. This band does not seem to lie flat, but is raised a little anteriorly.

The rostrum is stout and has four or five setae on each side, two of the longest have bulbous roots and are quiveringly vibratile. The lamella is trifid (fig. 3*f*), but only so seen when the rostrum tip is fully exserted, and pressed firmly against the cover-glass preparatory to pulling it away. Murray (10) states there are two separate lamellae, but the appearance of two is due to the middle part being hidden when the tip is only just showing. Before the grip of the glass is taken, the lamella is clearly seen with a fold in the middle, and not two separate parts. When the rostrum is tossed back, it has a peculiar appearance—two roundish parts in an almost rectangular casing.

There is a curious ribbon of thin skin, of considerable width, extending forward from the posterior of the rostral segment, and right round, at least dorsally and laterally. It stands clear of the segment at its front. Murray's figure seems to show it.

The antenna is stout and long, and equal to one-half of the neck width. There are three knobs across the top, and three brushes of short setae protrude; muscle or nerve threads pass up the middle. It is independently motile and it frequently gives a decided bend, the top segment also does so by itself. It is evidently very sensitive; for preparatory to exserting the head when the body is contracted, the antenna is gently protruded, and if it should meet an obstacle is drawn back, but again a second or even a third time it may be quietly pushed up to the obstacle, as if to ascertain its nature. The animal has evidently two very sensitive feelers: the antenna, and the cilia with the bulbous roots in the rostrum.

There are no eye-spots on the medium-sized brain mass.

The jaws are extremely large—1/520th inch—and somewhat heart-shaped; and the borders are thickened with rough brush-like extensions (Pl. 3, fig. 3*b*) often stained bright yellow. The four large teeth are pointed, and of a peculiar shape—swollen towards the inner ends and tapering off outwards. The fifth tooth is quite half the size of the largest, and the striae are very large. The double fulcrum (Pl. 3, fig. 3*e*) can be seen, during feeding, when the jaws are horizontal and open.

The vascular canals are prominent in the neck and are surrounded by a large amount of floccose matter, and there are at least five vibratile tags on each side. There may possibly be more, as the internal structure is not easily discernible on account of

the refractive, muscular, thick, fleshy integument, the deep plicae, and the small oil globules in the stomach investment. There are also minute round particles, like those so common in Floscularia, floating in the perivisceral fluid and streaming with every movement of the body. These often collect at parts and cause a reddish-brown appearance.

The rump is fairly long, but the anal and pre-anal segments are not well marked off from each other; the lumbar plicae, however, give some idea of how far the pre-anal segment extends (Pl. 3, fig. 3*d*). The intestine and contractile vesicle are thick-walled, but not particularly large for the size of the animal. Heavy foot glands and muscles penetrate through the anal segment; and two curious muscles seen over the contractile vesicle (fig. 3*d*) are apparently part of it, as they are pushed on to each other as the vesicle contracts.

The foot is longer than usual in the moss-dwelling Philodinae. There are four segments, through which pass two great glands and strong muscles. The spurs are characteristic, the interspace is slightly convex and equal to the width of the base of the narrow spur. The length of the spur is equal to the width of the segment at the point of attachment, but the spurs are attached not to the widest part of the segment, as is usual, but below it. I have never seen the form which has spurs exactly like *M. russeola* as figured by Murray. The toes are not far separated, the front two are enormous, and the other two much smaller. Cord muscles from each toe are very distinct, whether taut, or slack in loops.

The body is stippled in the most delicate and beautiful way. The stipples are exceedingly small and are arranged in rows so close together that, viewed at certain angles, as against the inside of a ridge, these rows look like delicate striae on a dental bulb. When the surface is viewed at right angles, the stipples are seen to be minute dots arranged in rows excessively close together. When the focus is slightly lowered, the appearance is that of hollows or tiny cells, and lower still the dots reappear. The middle focus—in good specimens—gives a brilliant effect, the perfect similitude of a miniature honeycomb whose cells have been reduced to almost infinitesimal dimensions. The stippling is difficult to make out on some specimens, but in general it is quite easy. Occasionally it can be seen most brilliantly on a dead shell or skin.

Philodina grandis is found in enormous numbers, occasionally, in isolated small pieces of moss. When there happened to be many on a slide, it was generally found that after a time they managed to congregate together in groups, as if fond of company. I have had as many as two dozen in view at once under the one-inch objective. They were lying stretched over and all about each other, some on moss with their heads down, others below with their heads stretching out, and nearly all feeding at the same time. Their coronae, all unfurled, swaying here and there, formed in the artificial light a most entrancing sight, flashing golden yellow amidst the green moss, and setting particles floating about in a perfect whirlpool. They seemed to take no notice when struck by a fellow Philodine, but decidedly objected to the impact of a swirling piece of moss.

Habitat.—Ground and rock moss. Uitenhage (Euphorbia Kloof), Grahamstown and Somerset East. Widespread and very numerous in isolated fragments of moss.

Philodina childi sp. nov.

Pl. 3, figs. 4–4*b*.

Specific Characters.—A very large and remarkably bulky Philodina; trunk of a dark brownish appearance. Rostrum stout. Antenna rather less than half the width of the neck. Trunk quadrate. Foot short and narrow—of five segments. First segment has two spurs set near each other. Toes four, short. Corona very large. Jaws large, teeth $\frac{1}{4}$ 2 $\frac{1}{4}$. Very delicately and clearly stippled. Size 1/40th inch.

This is, I think, the largest Bdelloid I have seen. I took it, for some time, for an overgrown variety of *M. quadricornifera*, as there is a considerable resemblance in general appearance. To my great surprise, however, when I observed it, after a time, creeping with its foot against the cover-glass, I discovered that it had four toes, and so was not a *Macrotrachela* after all.

Its length and bulk are both remarkable. It has a strong, thick muscular integument so that its shape retains wonderful uniformity, and varies little in outline. The lumbar region and posterior trunk are rather dark in colour, and almost opaque. It is a slow, laborious creeper and feeds freely. The rostrum is stout and has a large double lamella, each side of which has three

straight setae which quiver, but do not lash, and some shorter ones which were not seen to quiver.

The antenna is stout and fairly long, and the brain mass is small, far back and without eye-spots. Flocculent matter surrounding the vascular canals makes them very prominent in the neck. The jaws are elongated and bear four teeth on each side; two of these are very broad and large, and two—one on each side of the large ones—smaller but considerably larger than the extraordinarily large striae, and with well-defined points.

There are three ventral nucleated glands under the mastax, probably gastric. Two or three decided lateral ridges can be seen on the trunk, but there is no wrinkling when creeping. Quite characteristic is the shape of the lumbar region with stiff borders, and the anal and pre-anal segments not well marked off from each other. A long and convoluted stomach ends in a round and not very large intestine. The contractile vesicle is large and of fairly short period when feeding, and when it contracts crumples in towards the middle slowly. For so big an animal the foot is narrow; the spurs on the first segment are flat and triangular, and set very near each other. Somewhat similar to those of *M. quadricornifera* are the ordinary spurs, but less deeply cut between the tips, and more approaching a straight line. The four toes are short and stubby and not far separated from each other, the front two are the thicker (fig. 4*b*).

The corona is very wide-spreading and well over one-fourth of the length of the fully extended animal, and nearly as wide as that of *P. grandis*. The sulcus is slightly narrower than the wheel. A thin ridge or membrane with a V-shaped gap was seen ventrally between the pedicels, similar to that in *P. grandis*. Corona, collar and neck are to each other as 43, 31, 24.

The striking upper lip is rather complicated and will be best followed from the figure (Pl. 3, fig. 4*a*). No central setae were noticed on the wheels. *P. childi* is stippled in a manner precisely like *P. grandis*; the stippling is equally beautiful, with the same honey-comb appearance, and it is never difficult to make out; the trunk, lumbar region and spurs are the parts stippled.

An egg, very large, broadly oval, and dark in colour, was deposited on the slide five days after the animal was enclosed, and the division of the cells watched for some time.

There is another animal almost as large, which I have thought

might prove to be a variety of *P. childi.* It has a different upper lip, though it resembles it in several details, but I was unable to study it sufficiently.

Habitat.—Grahamstown. Very rare. Mr. Child, formerly of Uitenhage, used frequently to bring me moss from different places, and on one occasion brought the small piece of moss from Grahamstown which contained this animal, and I have named it after him.

I have never met with *P. childi* since, though I have had moss very frequently from Grahamstown.

Philodina nitida, sp. nov.

Pl. 5, figs. 9–9*a*.

Specific Characters.—Trunk rectangular; occasional specimens attain a large size. Lumbar region and foot rather light. Colour yellow, fairly deep in the older specimens. Furrowed longitudinally, but has a very smooth skin. Two large lemon-yellow eye-spots. Antenna long, between one-half and two-thirds neck-width. Jaws very large, with three great teeth and a fourth just smaller. Spurs of similar shape to those of *P. rugosa*, but held at different angles. Corona large; sulcus rather less than the disc; upper lip clear cut, distinctive. A seta on small pimple on each wheel.

Size, first samples, 1/70th inch, later examples up to 1/50th inch. This is an attractive, neat and dapper animal, modelled and built on clean lines, and has a clear, smooth skin giving a brilliant shining appearance. In the large specimens the colour is a deepish yellow all over, except the foot and lateral plicae, which latter are glassy-looking and fleshless. Frequently the deep shade occurs only in the alimentary track. Ovaries were seen of a pink tinge, and occasionally the wheels showed saffron.

It has a double lamella, rather small, and not so transparent mica-looking as usual; attached to the base of the lamella is a fleshy rim, also double, on which are situated a considerable number of setae, hardly, except two, projecting beyond the rostral sheath. These two and other two have bulbous roots, and have a quivering motion. The neck is very heavy and widens considerably at the dental bulb.

Scrubby setae are borne on the long antenna, whose two seg-

ments are nearly of equal length. Very large jaws—1/780th inch —carry four teeth each; three are very large and the fourth only just smaller; the striae are also large.

A good presentment of a fox's face is given by the brain mass, with its two large eye-spots. The trunk is rectangular—not much longer than broad in the earlier examples found—and has deep and numerous longitudinal furrows. The lumbar region is comparatively light for such a large animal, and has a thick-walled intestine, oval and very long; and a contractile vesicle which is fairly large.

The foot consists of four segments, and has spurs which are not unlike those of *P. rugosa* in shape, but more bent and decurved. Each spur is as long as the width of the ankle; a straight or scarcely perceptibly convex interspace separates the spurs, and is almost equal to twice the width of the spur base. The spurs seem to be feeble, and in all the earliest specimens one was twisted and not symmetrically placed with the other. Afterwards, the commonest form had the two spurs parallel, the outside border of one convex and the other concave. In one or two of the large examples last seen, the spurs were both convex on the outside borders.

No great distance separates the toes; the front ones are thick and fairly long, the back ones thin and short.

A large and well-developed corona is one-fourth of the length of the fully extended animal, and bears long cilia which play in great waves. In one giant example the corona was 1/180th inch wide, but the average width was about 1/250th inch. The proportions of the corona, collar and neck, are to each other in average specimens as 25, 20 and 15. The upper lip is distinctive. A lobe from the wheel meets the highest point of the upper lip; and occasionally a tooth jag or two show in the middle notch, but probably belong to the sulcus. A seta rises from a pimple on each wheel.

It creeps at a fair speed, and sometimes hitches the foot round and forward, with a swing. It feeds freely and usually lies back over the foot when feeding.

A long tongue-shaped gland lies below the mastax, ventrally. Heavy foot glands run high up into the anal segment.

Habitat.—Ground moss, the Hatchery, Stellenbosch. Found in fair abundance.

Philodina nitida var. *decens*.

Pl. 5, fig. 10.

This animal differs from the species in several points, but comes sufficiently near in jaws, upper lip and spurs to be considered a variety.

It is of a very elegant shape when creeping. It is large and stout, and has a heavy neck and fairly heavy rump. There is a large brain mass with two large yellow eye-spots.

The foot is short, and contains heavy glands. The spurs are in shape like those of *P. nitida*, but symmetrically placed; and of the toes two are large, and the other two much smaller. The rostrum is stout, and the double lamella, which is not very easily seen, bears several stiff setae. The antenna is rather thin and about one-half the neck width.

The teeth are exactly like those of *P. nitida*, and the striae are very large and easy to count—10 behind the teeth. There is a long tongue-shaped gland below the mastax.

There is little distinction between the anal and pre-anal segments. The intestine is oval and very long.

The corona is large and beautifully balanced; and the proportions of corona, collar and neck are to each other as 30, 20 and 15. The upper lip consists of two rounded lobes with a fair interspace. The wheels are frequently screwed, or brought nearer each other, causing serrations in the upper lip interspace. There is a slight prominence bearing a seta on each wheel.

The colour is faint pink and in some pale yellow. The pink colour is little more than a tinge, but the changing shades are wonderfully fine, as the animal doubles up and shows greater or less depth of flesh at parts, especially in the dental segment. Size, 1/50th inch.

Habitat.—Stellenbosch in ground moss.

Philodina inopinata sp. nov.

Pl. 4, figs. 6–6*b*.

Specific Characters.—Of small size, with long narrow foot, narrow cylindric trunk and stout neck. Antenna slightly longer than neck width. Of a glaucous colour. Two eye-spots. Teeth, three. Foot has five segments. Spurs of medium length,

narrow, almost parallel. Toes short. Corona scarcely wider than collar, sulcus narrow, upper lip triangular. There is a rectangular flap-like projection at the anus, which works as if on a hinge. Size, 1/90th inch.

The upper lip of this species is most difficult to examine, as the animal when feeding nearly always stands upright on its toes, and whirls round and round on its vertical axis; or swims about at great speed. It is a very timid feeder when moored, the corona is unfurled and almost instantly closed again, and this is repeated again and again, so that the merest glimpse of the upper lip is had. The corona is scarcely wider than the collar; the collar rises high up, and the pedicels are very short, causing some interference between the cilia of the primary and secondary wreaths. The upper lip is of an uncommon shape for *Philodina*. It is in shape a triangle extending as high as the discs, and lying well back into the sulcus. The stoutest part of the animal is that between the short, broad rostrum and the trunk—the dental segment is slightly the widest—and the trunk never gains the same dimensions as the neck, until after heavy feeding. It is a rather slow, deliberate creeper. The antenna is very long and generally hangs backward, with the terminal segment bending over, and when creeping gives a side view reminding one of that of a hare's head with the ears laid back. Some species of the genus *Rotifer* also have this appearance. Long setae are borne on the antenna, which is thickest half-way between the base and the second segment, as if swollen there.

There are brilliant eye-spots on the brain mass, well apart, slightly elongated and set obliquely. The trunk is closely plicate. Right from the trunk, the lumbar region and foot taper very gently all the way to the spurs.

Quite characteristic is a very peculiar process at the end of the anal segment. It is a thin, almost membranous, rectangular flap, somewhat bent in and over, on the top, so that the side view is that of a hook. When the animal is stretched to the full, the flap lies flat down, pointing forward over the contractile vesicle. As the animal relaxes, it stands upright, and turns down in the opposite direction when the foot is being planted. It almost seems as if the flap worked on a hinge. It is of the same colour as the foot, and thus easily overlooked. It was some time after finding the animal that I noticed it first.

The foot is a longish one of five segments, and bears on the penultimate segment spurs which are only just noticeably divergent, very narrow and acuminate, with narrow straight interspace, and equal in length to the ankle. The four toes are short and stumpy.

Habitat.—Draaifontein farm ravine pools, in company with *P. praelonga*. Found in abundance.

When I was examining the habits and characteristics of *P. inopinata*, I had rather a surprise on comparing my notes after having examined a good many specimens. The statements as to the spurs agreed fairly well, but those on the number of segments in the foot were sometimes five and sometimes four, on the number of the teeth sometimes three and sometimes two; and the length of the antenna was in some cases stated to be longer than the neck width, and in others shorter. In some, indications were noted of a triangular upper lip, in others not. It looked as if I had had, inadvertently, two species under observation. That there were two species turned out to be the case, but so alike in general appearance, habits, size and colour, that I had not even a suspicion of the fact until I noticed these conflicting details. Yet they are two very distinct species. *P. inopinata* has the spurs slightly more divergent, a longer antenna, one foot segment more, a tooth more, a narrower corona and sulcus, a different type of upper lip, and shorter toes. It has the flap near the anus, the other has not. It is quite extraordinary to find two species living together, so alike in general appearance and habits, and yet so distinct in almost every detail.

I have never met with *P. acuticornis*, but I think the second species referred to above might be considered a variety and I give a description under the name *odiosa*.

Philodina acuticornis Murray, *odiosa* var. nov.

Pl. 4, figs. 7–7*b*.

Specific Characters.—Neck short, trunk narrow, cylindrical; lumbar region and foot taper gradually from trunk to spurs. Foot consists of four segments. Spurs of medium length, practically parallel. Toes long, sharp, about equal in length, though possibly back pair rather longer. Eye-spots distinct. Antenna practically equal to neck width; with longish setae. Teeth, two

in squarish jaws. Corona rather wider than collar. Collar has flap extensions. Upper lip has a wide front gently sagging in the middle. Size, 1/90th inch.

Its habits when feeding are similar to those of *P. inopinata*, but if anything more provoking. The corona is rather wider, but the upper lip is more difficult to see, on account of its less sharp outline and its greater transparency. It rises about one-third up the sulcus. The rostrum is not very large, and the double lamella is far from prominent. The eye-spots are brilliant, somewhat elongated, and set rather closer together than those of *P. inopinata.*

The spurs are equal in length to the ankle width, and narrow to a sharp point, while the interspace is equal to the width of the spur base. Towards the points, the spurs curve upwards slightly but distinctly, a very uncommon occurrence.

It has a habit, when creeping, of throwing itself backward head over heels, with the four toes fully extended and gripping. Sometimes the two back toes are seen extended alongside and almost parallel to the spurs, and seem to be nearly as long (Pl. 4, fig. 7). All four toes are pointed.

This variety seems hardier than *P. inopinata* as it persists in the water and on the slides after the latter has died out, but loses much of its energy after a few hours on the slide.

Habitat.—Draaifontein farm ravine pools. Fairly abundant.

Philodina patula sp. nov.

Pl. 5, figs. 11–11*a*.

Specific Characters.—Stout, but not of great length. Colour lemon yellow, but only the merest tinge. Antenna equal to two-thirds neck width. Jaws not very large; teeth, two. Brain mass large, but no eye-spots. Lumbar region not heavy. Foot fairly stout, of four segments. Spurs parallel, very short, and without interspace. Corona very wide—almost twice collar width; sulcus rather wider than disc. Upper lip with a slight indentation. Size, 1/80th to 1/75th inch.

This is a vigorous animal and a very free feeder. The rostrum is long and stout, with a double lamella, and carries several long setae. The antenna is long and has a considerable tubular hollow

inside. The trunk laterally is slightly convex, and the posterior boundary always shows straight across with sharp corners. There are deep furrows laterally, the ridges not showing fleshy, but having a mica-like appearance; the dorsal furrows are broad and shallow. There is practically nothing to distinguish between the anal and pre-anal segments, which make up a comparatively light lumbar region. Both the intestine and the contractile vesicle are rather small. The foot is fairly stout, and the first segment is long and of a distinctive shape. It curves in and then out, ending in a distinct flange, which overlaps, laterally, the second segment. There are three of these flanges, and a good view can be had of them, when looking down the dorsal boundary, while the animal is feeding in a nearly perpendicular position. The first is at the posterior end of the trunk, and stands out very clearly; the effect is heightened by a broad hollow just in front of it. The second flange is at the back of the anal segment, and also stands well clear of the surrounding parts. The third is the one already described at the back of the first foot segment. They are very distinctive, and add to the general effect of the many graceful curves shown in the outline of this animal.

The spurs are very short, slightly blunt, parallel, and having an almost concave boundary between the tips.

The corona is an elegant one of large dimensions proportionately, the width being rather more than one-fourth of the fully extended animal. There is a single seta on each wheel, rising from a very small peg. Short pedicels support the wheels. The corona is to the collar as 22 : 13.

When the animal is feeding in a perpendicular position, and the upper lip looked down upon, the front margin of the latter shows two thick lobes, but when the animal is horizontal the anterior border approaches more nearly a straight line. This would seem to indicate that the lobes are much thicker, or deeper, laterally, and thin out towards the middle. There are two green granules in front of the rostrum, visible when the corona is unfolded.

The two teeth are not of great size. In some cases there is a third one, not much larger than the striae, but having a point which can be defined.

When the animal was anchored and feeding, the first two trunk segments were always seen with the peculiar frill arrangement shown in the drawing (Pl. 5, fig. 11).

The egg is a flat oval, with thirteen lateral prominences, or rather gentle swellings, three at the end are larger than the others. It is not unlike the egg of *P. plena*.

The only species at all like this one is *P. plena*. They are both tubby-looking animals when feeding, and have spurs and upper lips somewhat similar; but the peculiar shape of the foot and also of the first two trunk segments, the proportions of the corona, and the presence of the flanges, easily serve to distinguish *P. patula* from *P. plena*.

Habitat.—Ground moss, Grahamstown and Springfield Uitenhage district. Found abundantly, on one occasion only from each place.

Philodina rapida sp. nov.

Pl. 4, figs. 8–8*a*.

Specific Characters.—Of fairly large size; yellowish in colour. Heavy neck and lumbar region, with short stout foot. Antenna stout, and equal to one-half neck width. Teeth, three, medium size. Intestine very large. Foot consists of three segments. Spurs parallel and very short. Corona large with wide sulcus. Upper lip trifid. Size, 1/70th inch.

This species in general appearance is not unlike a *Macrotrachela*. Its heavy lumbar region and stout short foot chiefly contribute to the resemblance. It also creeps fairly fast after the style of a *Macrotrachela*. The rostrum is fairly stout and has several long setae, a double but rather small lamella, and cilia which have a habit of moving slowly when the animal is feeding. A thick antenna bears short stubby setae. There are three medium-sized teeth in the dental bulb, which is not very large.

The trunk is plicate and strongly muscular. Large glands extend through the foot and far up into the lumbar region. The intestine is extremely large, and the contractile vesicle of medium size, with a not very short period. The spurs are very short and parallel, with a concave line joining their tips. They very much resemble those of *P. patula*. The foot is very short, and of, apparently, three segments, and the toes are also short.

The corona is a handsome one, and large—about one-fourth of the extreme length of the body—while the sulcus is rather wider than the disc (7 : 6·5). Corona to collar is as 20 : 13.

The upper lip is broad anteriorly and has three lobes, or rather, small conical protuberances.

Habitat.—Rock moss, Euphorbia kloof, Uitenhage district. Rare.

Philodina proterva sp. nov.

Pl. 5, figs. 12–12*a*.

Specific Characters.—Of rather small size; glaucous in colour. Trunk heavy, but extremities rather light. Lamella fairly large and very transparent. Antenna short, about one-third of neck width. Brain mass large, without eye-spots. Dental bulb small with two medium-sized teeth. Lumbar region not very heavy; foot narrow and short, of four segments. Spurs very distinctive. Corona not wide-spreading, with sulcus about two-thirds of disc width. Upper lip wide in front and almost straight across. Size, 1/80th inch.

This is a very active and vigorous animal. It moves at very great speed, and is most restless, making it extremely difficult to examine. The trunk is not very transparent on account of the number of oil globules. It feeds voraciously—a perfect pig—and swells up into a barrel in a short time. It soon becomes so swollen and heavy that it has great difficulty in creeping, sometimes swinging right over sideways, as it tries to plant its foot forward. When feeding, it occasionally bunches part of the trunk forward, forming a constriction in the middle. The jaws work at such a tremendous pace, that one cannot even catch the flash of the teeth passing up and down.

Great circular muscles can be seen on the trunk and lumbar region, and some half-dozen longitudinal ones passing up into the cervical. The circular ones are very plainly visible, dorsally, over the ovary and eggs, but the stomach investment is too dense to show them well. There are some eight or ten in the trunk and lumbar region. The glistening of the muscles gives the trunk a very peculiar appearance in some specimens.

It has rather a short rostrum with great cilia. There is a large hemispherical granulated gland, attached to the posterior of the dental bulb. The contractile vesicle is large and of short period. The foot is short, and has four segments, the second and third being very short. Heavy foot glands extend far up into

the pre-anal segment. The spurs are convex on the outer borders and slightly divergent. There is a nick cut out in each inner border, and a bold convex interspace separates the spurs.

The corona is not wide, and not quite to collar as 5 : 4. Two membranes from the wheels come down into the sulcus, which is about two-thirds of the disc width. The upper lip is very difficult to trace, on account of its faintness, the refringent matter below and the rostrum generally overlying it. The restless waving motion also adds to the difficulty.

Habitat.—Ground moss, Salisbury, Rhodesia. Abundant in the one very small piece of moss I got from Salisbury. I have not seen it from anywhere else. It is very prolific. Along with this were two other species which had practically the same spurs ; one a variety of *M. quadricornifera*, and the other a variety of *M. musculosa*.

Philodina scabra sp. nov.

Pl. 6, figs. 13–13*b*.

Specific Characters.—Of extremely small size, short and stout ; of no distinctive colour. Trunk roughly furrowed, of gnarled bark-like aspect. Skin of trunk is evidently viscid, as particles adhere to the trunk. Corona narrower than collar, sulcus extremely narrow. Upper lip a flat curve with a small fleshy sharp peg-like protuberance in the middle. Antenna is equal to about one-half neck width. Foot short with four segments. Spurs are very distinctive and there are four on the penultimate segment. The dental bulb lies well back, and bears two teeth. Size, 1/180th inch.

This extremely minute animal, in general appearance and in details, corona and foot, looks much more like a species of *Macrotrachela* than a species of *Philodina*. I have it, in my notes, included among the *Philodina*, but have not made a distinct statement about the number of toes, as I usually do. I evidently, from my figures, did make out the number, but unfortunately omitted to state it, and as I have not seen the animal since 1908 I cannot now remember about the number of toes ; or whether it could have been placed among the *Philodina* by a slip, though I hardly think so. When the number of its toes is next made out, it may mean transfer to *Macrotrachela*.

It is rather slow in its movements, and prefers to keep under the rubbish, so that it is most difficult to find one when searching for it. It is practically a matter of chance to find one, even when one has got the moss containing it, as it is so small and generally has rubbish adhering. Evidently there were very few in the moss.

It is of shuttle shape, but not slender. The rostrum is fairly stout, with prominent setae under the double lamella. The rump and foot are stout, but do not give a heavy appearance. On the usual spur-segment there are four spurs of moderate length. The upper two are broad at the base and narrow to sharp points, and have an outside convex bend. Just below this pair, and a little inside, are two other spurs, about the same length but narrower at the base, gradually narrowing to sharp points, and straight. This is the only example of a Bdelloid having four spurs on one segment.

The corona is slightly less wide than the fairly prominent collar, and has an extremely narrow sulcus, and short pedicels. The upper lip is rather a flat curve rising up in the middle into a minute fleshy spike.

Habitat.—Tree moss, Van Staaden's pass, Uitenhage district. Rather rare.

Genus MACROTRACHELA.

Macrotrachela petulans sp. nov.

Pl. 6, fig. 14.

Specific Characters.—Of moderate size, but stoutly built. Colour hyaline, with pellucid granules on trunk, not very close together. Corona equal to collar, and sulcus to four-fifths of disc. Upper lip rounded, bifid with gentle dent. There is a seta on each wheel. Antenna stout, equal to one-third neck width. Jaws squarish; teeth three, large and well apart. Stomach a wide oval; intestine very large, oval. Foot stout, short, of three segments; last segment expanded into thick circular disc, wider than ankle. Spurs very small, divergent, with wide interspace slightly convex. Size, 1/90th inch.

The most outstanding feature of this sturdy little animal is the large, prominent, thick-walled, perfectly oval stomach. I have

seen nothing like it in any other Bdelloid. The wall is not rigid, nor strong enough to prevent it wrinkling when empty. It evidently discharges the contents under the shock of being placed on the slide, but before the slide can be examined all the specimens, perhaps dozens, are feeding vigorously, and soon are practically buried under a cloud of floccose matter. In less than a quarter of an hour the stomachs are all showing up as regular ovals, fully as broad as one-half the trunk width, each oval perfect and extending from mastax to intestine. Sometimes when Infusoria are devouring the contents of a dead specimen, the stomach and intestine, then evidently rigid, can be seen being knocked about, like a full-blown bladder with a smaller one attached, the walls quite distinct with a narrow connection between the two. This connection seems to be a thick muscular stricture of the walls of the stomach and intestine. When the stomach empties, the walls sag in; and when feeding again takes place, the walls behave pretty much as those of an elongated bladder when being slowly filled with air. After being a few hours on the slide the animals grow sluggish, seldom move away from their position and feed little. Some I could persuade to begin feeding at once by the addition of a little water.

It is a steady, fairly fast creeper, and with long strides plants its foot well under the head, and without any jerking.

The rostrum is short, but not particularly so. The lamella is double, but not very prominent, and being very diaphanous is not easily seen. There is a raised part surrounding the antenna, and sloping down to the lateral borders of the segment, and the antenna protrudes only a short distance outside this.

There is a large wide brain mass. The teeth are quite large, widely separated, and easily defined. In no specimen did I ever see any departure from three as the number of teeth.

The trunk and rump are granulate with not very large granules, which are pellucid or pearly-looking and accordingly not very conspicuous, nor difficult to overlook. These granules are not very close together and are rather irregularly arranged.

The lumbar region is fairly heavy, but not swollen-looking, and the contained contractile vesicle is round and very large; and when expanded fills up practically the whole of the anal segment. The spurs are very small and very divergent. In some positions, the interspace forms practically a straight line with the inferior

borders of the spurs, but usually the wide interspace curves just enough to appear convex.

The corona is bold, with a sulcus equal to four-fifths of the disc, and the relative proportions of the corona, collar and neck are 11, 10, 8½. The rounded upper lip has a gentle depression in the front margin, and just covers the bridge of the sulcus when the animal is horizontal. There is a small fleshy tooth in the sulcus, generally hidden, and two membranes come down from the wheels to near the middle of the sulcus bridge. There is a distinct lip flap at the collar.

The only Bdelloid at all near to this is *C. asperula* Murray (8). In general appearance and in some details they are very similar. *M. petulans*, however, has a distinctly different type of spurs; has not got an exceptionally short rostrum; has not the sharp points on the upper lip, nor any peculiar shape of the first trunk segment. It has a visible lamella, and the teeth never were found to vary in number from three; nor do the jaws show any constriction. The most essential difference, however, is in the character of the stomach. Murray had evidently paid particular attention to the width of the lumen, as shown in his descriptions of *C. armillata*, *C. lepida* and *C. microcornis* (7, 9). Having thought it worth while to note these not very greatly enlarged instances, he was not likely to have overlooked such a departure from the common, had it existed in *C. asperula*. With regard to *C. asperula* he neither mentions nor shows in his figure a wide lumen; besides, he had previously seen my sketch of *M. petulans*, and would have kept an outlook for this distinctive feature.

Habitat.—Tree and rock moss. Widely spread and abundant at times. Grahamstown; Uitenhage district at Bulk River, Springfield, Van Staaden's pass and Draaifontein farm.

Macrotrachela cuthberti sp. nov.

Pl. 6, figs. 15–15*b*.

Specific Characters.—Of moderate size, and rather under medium stoutness. Antenna very short, equal to one-fourth neck width. Jaws small, square with three strong teeth. Contractile vesicle large. Foot short, of apparently three segments. Spurs small, sharp and scarcely divergent. Corona just visibly

wider than the collar. Sulcus narrow. Upper lip quite distinctive. Size, 1/90th inch.

This is a vigorous, active animal and feeds freely, and is of a pale hyaline colour. It is of a semi-muscular type, for while the muscular integument is sufficiently strong to keep a fairly regular shape when creeping, yet occasionally the trunk loses its ovoid form when feeding.

The corona is bold and handsome. It is hardly wider than the collar, has a narrow sulcus and rather high pedicels. It is difficult to get a good view of the upper lip on account of its smoothness and glassy colour, and of the restless habits of the animal. The part of the upper lip which rises up from the flat curve looks somewhat like two stout rose thorns set against each other. The small tooth process in the middle of the curve between is not always seen, and this probably indicates that it is on the sulcus bridge. Lateral flaps are seen at the collar, and there is a large oral entrance with a spout-shaped under lip.

The rostrum is fairly stout, and the double lamella prominent. The antenna is very short, about one-fourth the neck width, and almost as broad as long. Quite characteristic is the small, square dental bulb, with very broad, thick even outline or borders, and it carries three strong, thick teeth set well apart.

The rump is not heavy, and the pre-anal segment has a wrinkled mark on each side. The contractile vesicle is very large. The foot is short, and its spurs are sharp and practically not divergent. From tip to tip, the outline is a rather flat concave, but at times the appearance is of two short cones with a short, straight interspace.

Habitat.—Fairly common in ground moss from Stellenbosch and Mulder's Vlei.

I have named this species after Mr. J. R. Cuthbert of Stellenbosch, who kept me supplied with moss from his neighbourhood.

Macrotrachela macmillani sp. nov.

Pl. 6, figs. 16–16*a*.

Specific Characters.—A plump little animal, of glaucous colour, with a slightly yellowish stomach investment. Each longitudinal ridge on the trunk has four deep bends in it; these deep dents seem to connect crosswise, giving the appearance of five

transverse rows of tiles or overlapping plates on the trunk. Rostrum very stout. Antenna short, about one-third neck width. Teeth, 3/4. Foot of four segments. Spurs short, sharp with wide, flat interspace. Corona slightly wider than collar. Upper lip has a broad front margin with a gentle indentation. Size, 1/100th inch.

This little animal has a most extraordinary yet attractive appearance. Viewed from the front and looking downwards, the trunk seems protected with five transverse rows of tile-like parts overlapping posteriorly. These parts are not excrescences, or foreign to the trunk as in *M. incrassata*, but the true skin, ridged and bent into these little oblongs, as is made apparent by the alteration of their shape with every movement of the body, especially when creeping. If looked at sideways, when the animal is feeding horizontally, the dorsal crests and hollows can be seen, and it can be noticed also that the borders of the crests, instead of curving down gradually to form the hollows, suddenly bend straight down or even backwards, causing the appearance, already mentioned, of tiles overlapping. The top edges or rims of the ridges are easily focused, and are of a glaucous green colour, contrasting sharply with the grey between. These loops appear also on the rump with a little variation, but of a permanent character, and are triple in the anal segment.

M. macmillani is a fast creeper, with a short glide or slither with each step; and it feeds freely and quietly.

The rostrum is stout with a double lamella which stands out clearly. The antenna is short and exceptionally broad at the base. The jaws are not very large, are winged and have three teeth in the one and four in the other. When the animal is creeping, the neck shows quite a distinctive shape. There is a gradual curve from the rostral to the dental segment, the narrowest part being about half-way between.

The rump seems to have three divisions, but not very markedly so, and it is somewhat doubtful what belongs to the anal and what to the pre-anal segments, though probably the anal is very large and consists of two of these apparent divisions. The intestine and contractile vesicle are both large. The spurs are short with a wide, flat interspace. There is a short foot of four segments, and on the last segment there is a ring expansion, but not large enough to show outside the ankle, as in *M. petulans*.

The corona is bold, and has a sulcus rather wider than half the disc, and the proportions of the corona, collar and neck are to each other as 10, 9, 7.

The upper lip rises above the sulcus bridge, has a broad front, with rounded corners and a shallow indentation in the middle. There is a thick, short, fleshy tooth in the sulcus.

The trunk is stippled.

The egg is broadly oval, with round knobs somewhat like those in *P. plena*, but more numerous—about fourteen.

Habitat.—Rock moss, Grahamstown. On the first occasion when I found this species I saw only some three or four, and put my notes aside, lest it should prove a freakish or unstable variant; but on a second occasion it was found in great numbers, and frequently as many as a dozen were seen on a slide. It does not seem, however, to be widespread, as out of the large number of pieces of moss examined only one small piece on each of the two occasions contained any.

Professor Macmillan, Grahamstown, sent me the moss on both occasions, and I have named the species after him.

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DESCRIPTION OF PLATES.

Plate 2.

Fig. 1. *Monoceros falcatus*, side view.
,, 1*a*. *Monoceros falcatus*, dorsal.
,, 1*b*. *Monoceros falcatus*, head, ventral.
,, 1*c*. *Monoceros falcatus*, jaws.
,, 1*d*. *Monoceros falcatus*, toes and spur, ventral.
,, 2. *Didymodactylos carnosus*, dorsal.
,, 2*a*. *Didymodactylos carnosus*, corona.
,, 2*b*. *Didymodactylos carnosus*, spurs, and toe orifice.
,, 2*c*. *Didymodactylos carnosus*, toes exserted.

Plate 3.

Fig. 3. *Philodina grandis*, dorsal, feeding.
,, 3*a*. *Philodina grandis*, ventral, creeping.
,, 3*b*. *Philodina grandis*, jaws.
,, 3*d*. *Philodina grandis*, rump, dorsal.
,, 3*e*. *Philodina grandis*, jaws after treatment with potash.
,, 3*f*. *Philodina grandis*, lamella and setae.
,, 3*g*. *Philodina grandis*, left side corona, more enlarged.
,, 4. *Philodina childi*, dorsal.
,, 4*a*. *Philodina childi*, corona.
,, 4*b*. *Philodina childi*, toes and spurs.

Plate 4.

Fig. 5. *Philodina praelonga*, dorsal, feeding.
,, 5*a*. *Philodina praelonga*, dorsal, creeping.
,, 5*b*. *Philodina praelonga*, toes extended.
,, 6. *Philodina inopinata*, dorsal, feeding.
,, 6*a*. *Philodina inopinata*, dorsal, creeping.
,, 6*b*. *Philodina inopinata*, jaws.
,, 7. *Philodina acuticornis* Murray, var. *odiosa*, dorsal.
,, 7*a*. *Philodina acuticornis* Murray, var. *odiosa*, jaws.
,, 7*b*. *Philodina acuticornis* Murray, var. *odiosa*, toes extended.
,, 8. *Philodina rapida*, dorsal.
,, 8*a*. *Philodina rapida*, corona.

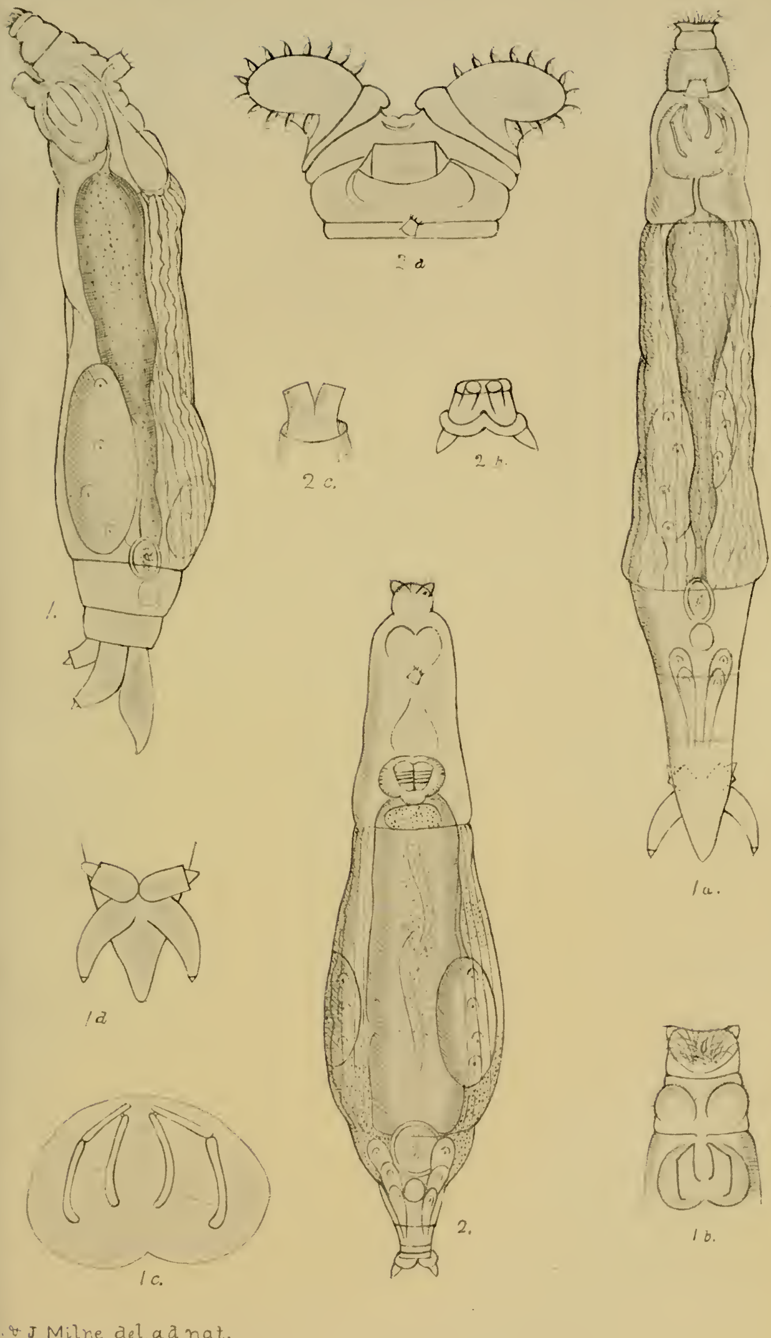
Plate 5.

Fig. 9. *Philodina nitida*, dorsal, feeding.
,, 9*a*. *Philodina nitida*, dorsal, creeping.
,, 10. *Philodina nitida*, var. *decens*, corona.
,, 11. *Philodina patula*, dorsal, feeding.
,, 11*a*. *Philodina patula*, dorsal, creeping.
,, 12. *Philodina proterva*, dorsal, creeping.
,, 12*a*. *Philodina proterva*, corona.

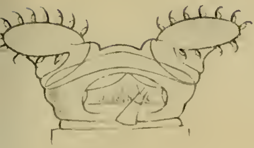
Plate 6.

Fig. 13. *Philodina scabra*, dorsal, feeding.
,, 13*a*. *Philodina scabra*, spurs, dorsal.
,, 13*b*. *Philodina scabra*, spurs, side view.
,, 14. *Macrotrachela petulans*, dorsal.
,, 15. *Macrotrachela cuthberti*, dorsal.
,, 15*a*. *Macrotrachela cuthberti*, corona.
,, 15*b*. *Macrotrachela cuthberti*, jaws.
,, 16. *Macrotrachela macmillani*, dorsal, feeding.
,, 16*a*. *Macrotrachela macmillani*, dorsal, creeping.

Where proportional numbers are given in the text, each unit represents 1/6000th inch.



Bdelloid Rotifera of South Africa.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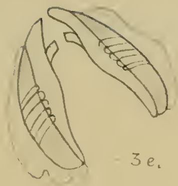
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4 b


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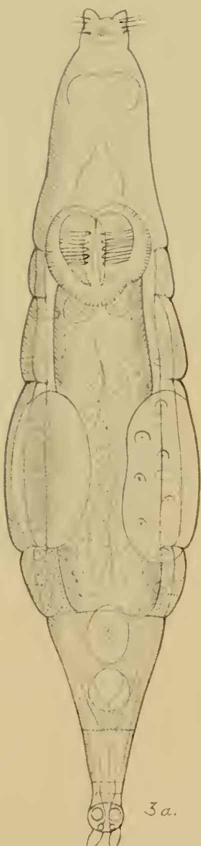
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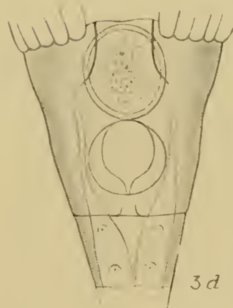
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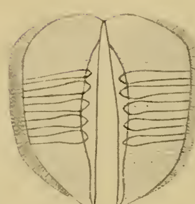
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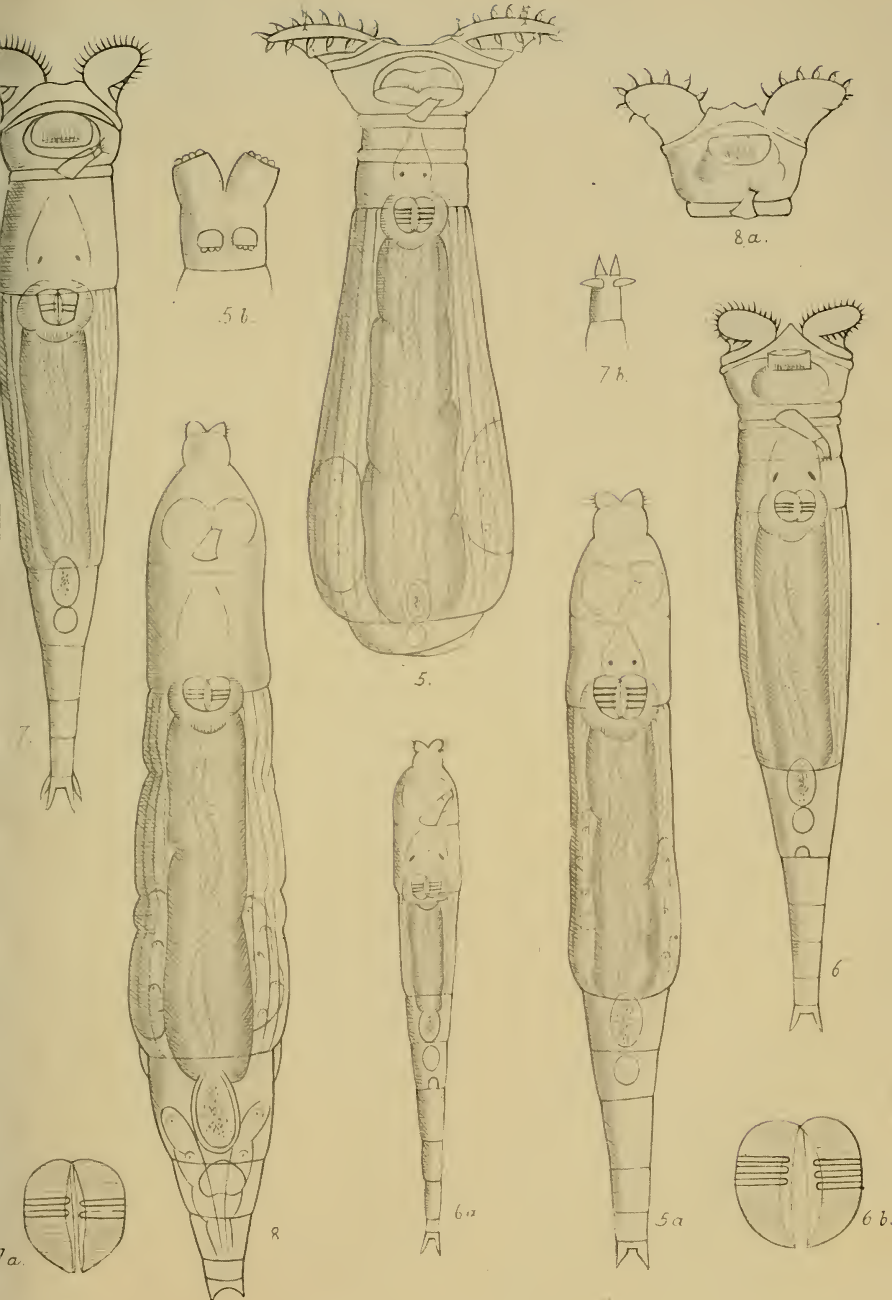

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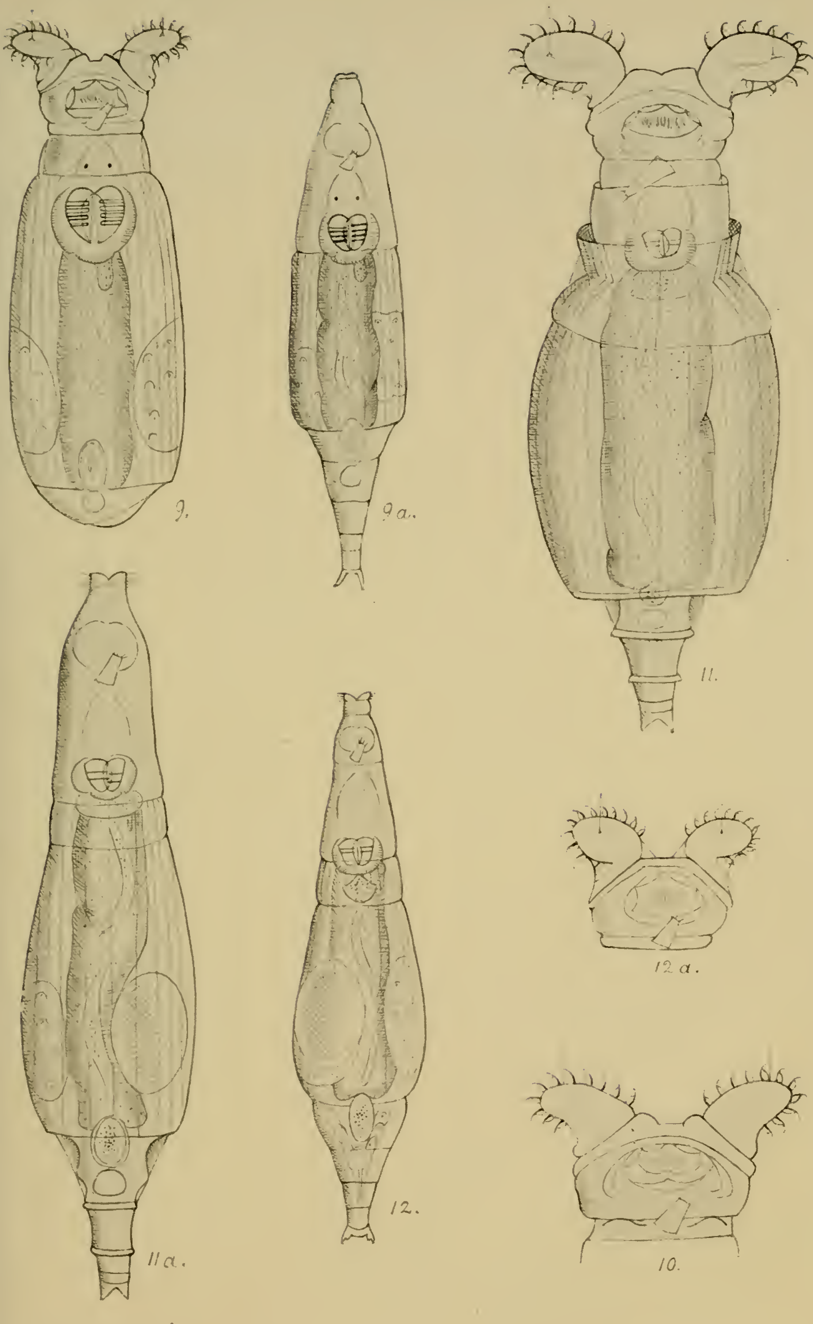

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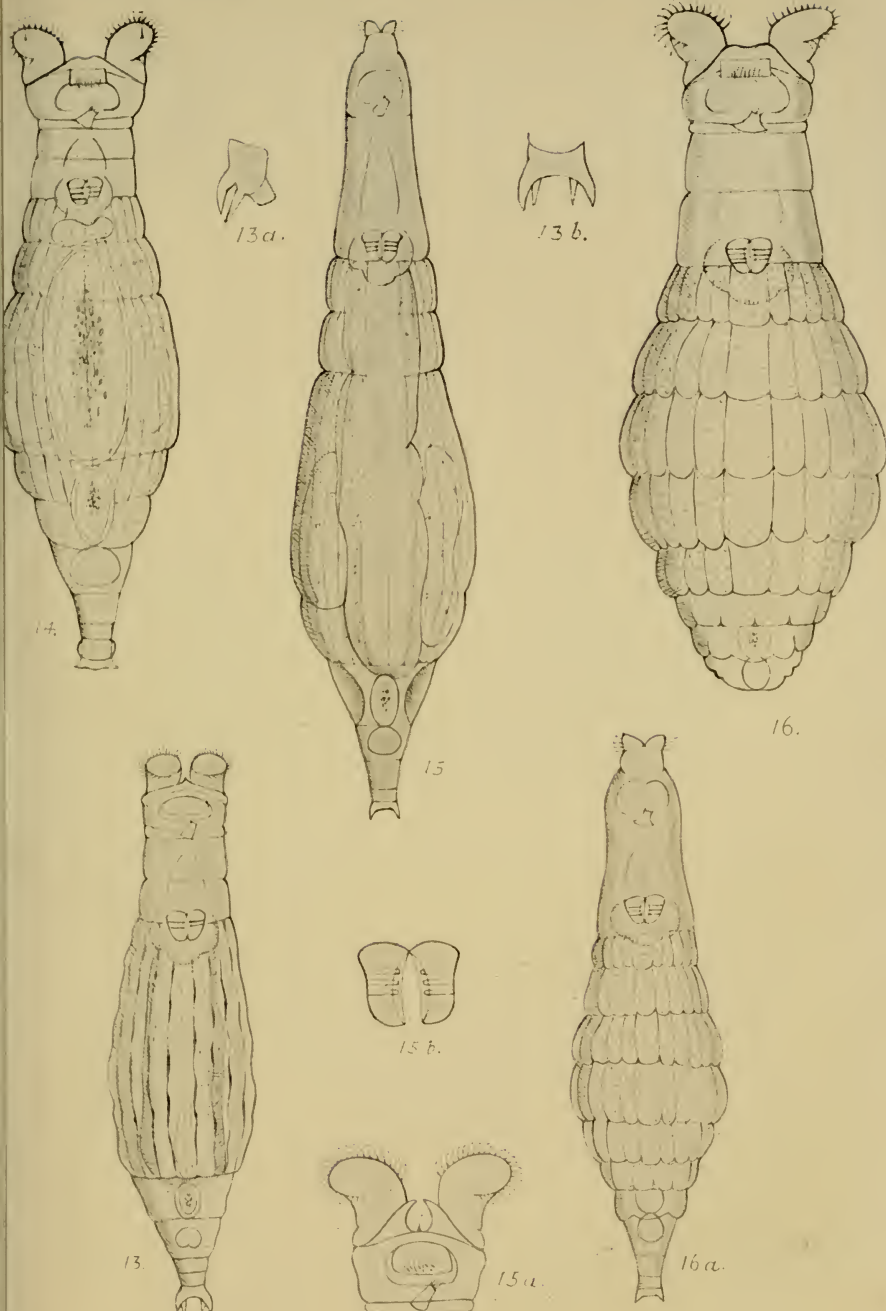

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Bdelloid Rotifera of South Africa.

A SIMPLE TROUGH FOR POND LIFE.

By J. T. Cook.

(*Read December 28th,* 1915.)

Figs. 1, 2.

The little piece of apparatus figured below is intended for use as a trough for pond life, and is suitable for low powers. The

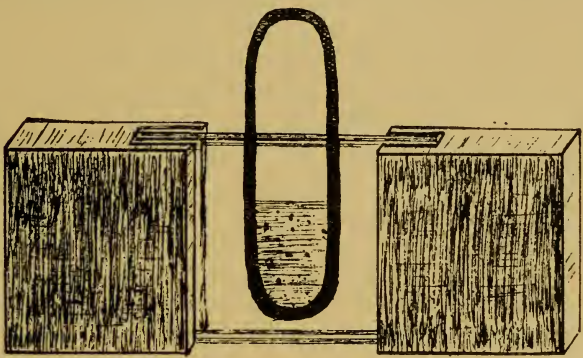


Fig. 1.

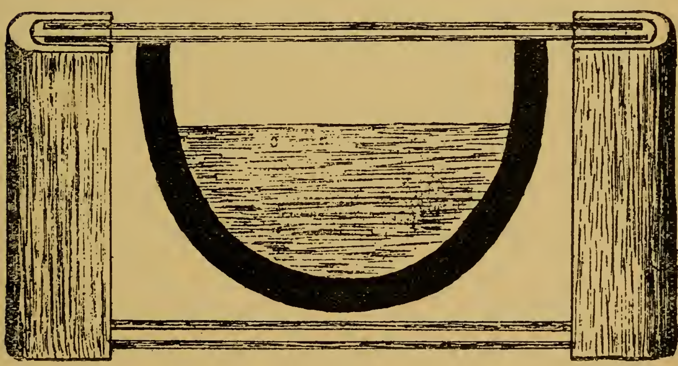


Fig. 2.

following details may enable any one so desirous of constructing a number for himself. Take a glass slip, 3 × 1 in., and cut it

in halves ; also a piece of hard wood, such as mahogany, $\frac{3}{8}$ in. thick, and from this cut a piece 6 in. long and 1 in. wide. Next cut a shallow groove about $\frac{3}{8}$ in. deep along one of the edges just sufficiently wide to take the two pieces of glass. Then divide the slip of wood into six sections, which will provide material for three troughs. A small rubber ring, preferably square in section, is placed between the glass slips in the position shown in the figure, and the edges of the glass slips are then fitted into the grooves in the edges of the square of wood, in such a way as to hold the rubber ring in position and to render it water-tight. Should the grooves be insufficiently wide to receive the glass slips, they may be increased slightly in width by the use of a flat file. The writer has kept specimens of pond life in these troughs for many weeks simply by adding a small quantity of fresh water every other day. The lower figure represents a trough in which the glass slips used are $3 \times 1\frac{1}{2}$ in., and by their use a larger trough is obtainable. Of course, in this case the original slip of wood is $1\frac{1}{2}$ in. wide instead of 1 in. as in the smaller size described above. They are only intended for use with low powers up to say $\frac{1}{2}$ in. ; but as much of the work on pond life is done with 1-in. objectives, they will be found very useful. The advantages of such a trough are found in their extreme simplicity and cheapness ; any one can make them, also they can be taken to pieces for purposes of cleaning without any fear of breaking.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 510th Ordinary Meeting of the Club, held on October 26th, 1915, the President, Professor Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on June 22nd were read and confirmed.

Mr. Ernest Quarry Bilham was balloted for and duly elected a member of the Club.

The President announced that for the present it had been decided by the Committee to commence the business of the Meetings at 7.30 p.m. instead of 8 o'clock. The Committee will meet at 7 o'clock p.m.

The President paid tribute to the memory of the late Prof. Edward Alfred Minchin, M.A., F.R.S., who was a former President of the Club, and who died at Selsey on September 30th, 1915.

He stated Prof. Minchin was the most conscientious investigator he had ever met. In the study of Spongology, his most striking contributions were on the histology and embryology of the Calcarea, especially those dealing with the triradiate spicules, or rather spicule-systems, as he proved them to be. His most important memoirs on Sponges were produced while he occupied the chair of Zoology at University College, London. Before resigning this chair and accepting the newly-created chair of Protozoology in the University of London, and making his headquarters the Lister Institute of Preventive Medicine, at Chelsea, he visited Uganda as a member of the Royal Society's Commission on Sleeping Sickness. His *Introduction to the Study of the Protozoa*, published in 1912, will long remain the standard treatise on this important subject. Besides being President of the Club, he was also Vice-President of the Zoological Society, and latterly Zoological Secretary to the Linnean Society.

A resolution of deep regret was passed by the members, who

also expressed their sincere sympathy with Mrs. Minchin in her great loss.

Mr. A. E. Hilton then read a paper on the "Formation of Sporangia of Stemonitis."

This form of Mycetozoa is one of the most abundant in the world. It is easily recognised by the dark brown sporangia, usually 1/2 to 3/4 in. high, generally crowded together on slender black stalks.

In Stemonitis the stalk is continued upward as a columella nearly or quite to the top of the sporangium. From this the capillitium branches in all directions and surrounds the sporangium with a surface network of extremely delicate meshes, through which the spores finally escape. The specimen described here was gathered last August, after the heavy rains, in Highgate Woods, from an old tree stump, near the top of which appeared an old black and leathery fungus with patches of milk-white plasmodium, which seemed to have oozed from the stump.

The paper was illustrated by sketches and photographs showing the various stages of development and specimens of the same were exhibited.

A vote of thanks was accorded Mr. Hilton for his description of the interesting observations he had made.

The President said that being interested in the subject himself, he was very anxious that some of his fellow members should also be interested in the study of sponges, and with the idea of awakening such interest, he proposed to give a series of short addresses on the subject, and with a view of stimulating examination he proposed to bring some material to the meeting for distribution amongst the members, and hoped they would have a flood of light thrown on the subject of sponge spicules. He had often thought that very much work was done in connection with diatoms amongst the members, and he thought that if some of the energy expended in this direction was put into the study of sponge-spicules, some good results might follow. The matter had been brought before the Committee, who had decided that at the next Ordinary Meeting of the Club the first of these addresses should be given.

In the absence of the author through ill-health, the Hon. Secretary then read a paper on "Five New Species of Rotifera," by Mr. David Bryce,

They are all of the genus Habrotrocha, and are named: *H. insignis*, *H. sylvestris*, *H. pavida*, *H. flava*, *H. longula*.

The President complimented Mr. Bryce on having added five new species to the Bdelloid fauna, and a vote of thanks was accorded him by the members for his paper.

At the 511th Ordinary Meeting of the Club, held on November 23rd, 1915, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on October 26th were read and confirmed.

Messrs. Geo. W. King, John Geo. Bradbury and Arthur P. Drake were balloted for, and duly elected members of the Club.

A letter was read from Mrs. Minchin in acknowledgment of the resolution of sympathy transmitted to her from the last meeting.

Mr. W. R. Traviss exhibited and described a new adaptation to Swift's well-known portable microscope. He stated that from time to time various modifications had been effected in the instrument, always keeping in view, however, the retention of its portability. The latest was that of a binocular body. This is effected in a very novel and ingenious manner, which allowed the instrument to be folded up so that it required only the same small leather case as the monocular. The eye-pieces are of the usual Continental size. The draw tubes pull out separately for adjustment to the different inter-pupillary distance of the user's eyes, and are marked in millimetres, thus enabling the distance to be registered for future reference. The Wenham Prism is that known as the short body prism. He also exhibited another prism which can be supplied for placing over the eye-piece, which effects a more comfortable adjustment in some cases, and by a slight rotation remedies a not uncommon defect in observers' eyes, where there is a want of agreement in the visual planes. Several members spoke with much approval of the arrangement. Mr. Ainslie thought the instrument was a very beautiful little thing, and congratulated Mr. Traviss on the design. He especially praised the prism adjustment, which he had found enabled him to use the binocular with great comfort, and had no doubt that many who experienced a difficulty in

using a binocular would find it of great service to them. The President proposed a vote of thanks to Mr. Traviss for bringing the model to the notice of the meeting. This was carried unanimously.

The President then invited Vice-President D. J. Scourfield to take the chair.

Prof. Dendy said he did not intend to give a formal lecture, but hoped to give a series of short addresses, as opportunity occurred, on sponges, especially from the point of view of microscopists. Although sponges are undoubtedly animals, there is some controversy as to their position in the animal kingdom. Some have held that they are Protozoa ; in Germany they are considered as a group of Coelenterates. Prof. Sollas styled them "Parazoa." No doubt they form an isolated group, and do not link on to any of the other groups very closely. They have affinities with the Protozoa, but may be regarded as taking a higher position. They form a large group ; it is impossible to say how many species there are, but it is an enormous number, almost comparable to the insects in diversity of form and structure. They are of particular interest because we can trace out in them the lines of evolution, and he wished to treat them from this point of view, especially as regards the spicules. The Calcareous sponges include the simplest of all the types (Leucosolenia). This is a tube whose wall is composed of three layers. The outside one, called the ectoderm, is generally found to be formed of flat cells ; these pavement cells may become amoeboid. The inside layer—the endoderm—is the most characteristic feature ; it is composed of collared cells. These are in structure like the collared flagellate Protozoa—the Choanoflagellata. Between these two layers is a stratum of mesogloea with cells embedded in it, some of which secrete the skeleton composed of the spicules which support the body. In the Calcarea these are formed of carbonate of lime and are of various shapes. In life a stream of water is taken in through small pores in the body wall, and is ejected through the large terminal opening or osculum. This stream is maintained by the action of the collared cells. The water is swept out of the gastral cavity, removing waste products, while the incoming current brings in particles upon which the cells feed and also oxygen for respiration. This is a very simple form, and com-

plication arises chiefly from budding and colony formation. The degree of complication of the canal system may be taken as an indication of the degree of evolution of the whole sponge. An ordinary bath sponge is a more complicated organism and it is impossible to say how many individuals it represents. You cannot define individuality. Sponges may be divided into five great groups: first, those with calcareous spicules, the Calcarea; second, those which have no skeleton at all, the Myxospongida, very primitive forms; third, the Triaxonida, with skeleton composed of siliceous spicules having three axes and six rays; fourth, the Tetraxonida, with siliceous spicules having four axes and four rays, radiating at equal angles from the centre; fifth, the Euceratosa, in which the skeleton is composed of horny fibres and there are no spicules. The spicules originate in mother cells. The mother cells are found in the mesogloea, the substance between the ectoderm and the endoderm. They are not always the product of one cell only. There is a spicule which reaches the length of 3½ feet, and is of nearly the thickness of a lead pencil. One mother cell could hardly give origin to this, and it is not known how it arises. Siliceous spicules are formed of opal, secreted by the protoplasm of the cell. They are arranged in a scattered manner in the simplest cases. By reference to diagrams, it was shown how from the primitive tetraxonid form with four rays —like a calthrops—a great number of shapes are derived. One ray may be elongated while the others remain short (triaenes); three rays may be suppressed, leaving only one, which may acquire a head. Many other varieties were described and illustrated by sketches and by large diagrams. In most sponges the spicules are divided into two categories, skeleton spicules (megascleres) and flesh spicules (microscleres). Flesh spicules are of interest because it is so difficult to conjecture what can be their use. They are very beautiful and constant in form. A great number of shapes were pointed out on the diagrams, the method of their origin from simpler forms being described and illustrated on the blackboard. Prof. Dendy had brought for distribution among the members a tube containing a sponge from the Indian Ocean—*Dercitopsis minor*—which would afford interesting examples of some of the more primitive tetraxonid spicules.

At the invitation of the Chairman many of the members asked the President questions on various points, to which he replied. Mr. Scourfield said the President had given them a most interesting communication, and the study of the material would afford them plenty of work. Such a paper was quite a new feature in the proceedings of the Club, and a very welcome one. He proposed a very hearty vote of thanks to the President, which was carried by acclamation.

At the 512th Ordinary Meeting held on December 28th, Vice-President C. F. Rousselet, F.R.M.S., in the chair, the minutes of the meeting held on November 23rd were read and confirmed.

Mr. John Syer was balloted for and duly elected a member of the Club.

After the usual preliminary business had been gone through, Mr. J. T. Cook exhibited a novel form of trough for pond life which he had designed, and from considerable use had found very successful. It may be made of almost any size that is desired, but dimensions that can be constructed from the ordinary 3 × 1 in. slips are advantageous, as every microscopist has these at hand. Two slips should be taken, and between them an indiarubber ring, such as is used for putting round papers, etc., should be enclosed. It may be left entire with a part projecting above the top of the slips, or a segment can be cut of a suitable size which will lie wholly within their breadth. The ends of the slips are then clipped together by a piece of hard wood, about 1 in. square, in which a groove had been cut of the requisite width to hold together the glass slips and put some slight amount of pressure on the rubber ring, and so prevent leakage. Obviously the ring may be of greater or less thickness, thus varying the capacity of the water space from front to back, while a broad or narrow space can be obtained by its adjustment to suit the purpose in view. Mr. Cook showed a variety of sizes, with different shapes of internal construction. He stated that among the advantages of this trough are that they are so simple that any one can make them ; cheapness—the cost of the materials being altogether negligible ; ease of cleaning—the only requisite being to slip off the wooden clips, when the glasses can be wiped, and all replaced with a minimum of trouble ; and, perhaps

greatest of all, their ready construction of any suitable form and size for the requirements of a particular case. The only part to wear out is the rubber ring, and that will last a considerable time. Mr. Cook had frequently had a trough in use for many weeks, containing organisms whose development he wished to watch. Several members spoke in appreciation of the advantages of the little apparatus, and a hearty vote of thanks was passed to Mr. Cook for bringing it before the meeting.

Mr. Burton then read a short paper, "Notes on the Aleurodes Fly." The Cambridge Natural History definition of the family is, "Minute insects with four mealy wings, seven-jointed antennæ, two-jointed feet, terminating in two claws and a third process." Mr. Burton said the subject was not quite new to the members, as Mr. R. T. Lewis, in 1895, described and figured a new species that had been sent to him from Natal. It was named *Aleurodes asparagi*, having been found on plants belonging to the genus Asparagus in Natal. The paper was a most useful one, and gave more detail than any other with which he was acquainted. It will be found in the *Quekett Microscopical Club Journal*, vol. vi., second series.

Mr. R. T. Lewis said, with reference to the destruction of a pest by the introduction of its enemies, a case in point occurred in connection with the notorious *Icerya purchasi*, which, having been introduced into South Africa, had affected the orange and lemon trees over a district of 800 square miles. Laws were passed requiring infected trees to be cut down and burnt; but the inhabitants, whilst they cut them down, dragged them through the villages for firewood, and so distributed the insects still further. The discovery of the male determined that it was the Australian species which had been imported, and, finding that in Australia the *Icerya* was kept down by a species of *Rodolia* (one of the Lady-bird tribe), large numbers of these insects were imported, and now the pest was reduced to manageable limits.

A vote of thanks was passed by the members for Mr. Burton's paper and interesting exhibits.

At the 513th Ordinary Meeting, held on January 25th, 1916, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the

minutes of the meeting held on December 28th were read and confirmed.

Mr. Theodore Stephanides was balloted for and duly elected a member of the Club.

A list of the officers nominated by the Committee for the coming year was read. As far as possible they were the same as in 1915, with Prof. Dendy again President. This announcement was received with marked satisfaction by the members present. Nominations for filling the vacancies in the Committee were then made. Mr. Grundy was proposed by Mr. Wilson and seconded by Mr. Beston; Mr. Gabb was proposed by Mr. Rousselet and seconded by Mr. Brown; Mr. Paulson was proposed by Mr. Sheppard and seconded by Mr. Bryce; Mr. Soar was proposed by Mr. Perks and seconded by Mr. Grundy; Mr. Ainslie was proposed by Mr. Watson-Baker, Jr., and seconded by Mr. Offord.

The President said he regretted to have to announce the recent death of one of their members. Mr. G. K. Dunstall joined the Club in 1910, died on January 9th. He was chiefly interested in Rotifers.

It was moved by Mr. Wilson and seconded by Mr. Bryce that a vote of condolence be sent from the club to Mrs. Dunstall. This, having been put to the meeting by the President, was unanimously agreed to—all standing.

The hon. secretary read a paper by Mr. G. T. Harris, of Sidmouth, "On the Collection and Preservation of Desmids." The paper referred to the frequent complaint of the uninitiated of their lack of success in obtaining desmids. It was remarked that this was probably due rather to the method of collection than to any actual scarcity in the objects. Their presence in various situations was noted, and the fact that the ordinary ring-net, as used by collectors of microscopic organisms, was not well fitted for use in many of them. Prof. West's suggestion of clipping the stems of aquatic plants under the surface of the water between the closed fingers and drawing the hollowed hand carefully up, making of it a cup in which the flocculent matter is caught, was approved of. If the collecting excursion is of a day's duration only, the ordinary supply of tubes and bottles will suffice, and the material may be brought home in the water in which it was found. If the excursion is more extended, however, the

number of tubes and bottles required becomes inconvenient and subject to disaster by breakage. Under these circumstances, therefore, the author had adopted the plan of killing and fixing the desmids where they were collected, and he had found this quite satisfactory. The method is as follows: A small funnel to support filtering material is essential. It was found that the best material for the filter was chamois leather, which has the advantage that it allows of the residue left, after the water has run off, being scraped up with a spatula without risk of tearing the filtering material. The filtered residue may then be placed in tubes (3-in. by 1-in. is a convenient size), each numbered to correspond with notes giving the name of the locality and the habitat, as bog, moor pool, pond, etc., with any other desired particulars. When what is deemed a sufficient amount has been placed in the tube, this should be nearly filled with clear water and about 4 cubic centimetres of the following killing and fixing solution should be added:

Cupric sulphate (10 per cent. solution) . . .	100 c.c.
Mercuric chloride (saturated solution) . . .	10 c.c.

Extreme accuracy in the quantity added is not necessary, and a little practice soon enables one to estimate the right amount. The only drawback connected with this method of treatment is that the material is apt to become too concentrated. Care, therefore, should be taken not to place too much in a tube. As in about 10 cubic centimetres of filtered material obtained from one small unimportant bog over one hundred species and varieties of desmids were found, it is obvious that this is a very practical and productive method. Large, old-established bogs yield the best results, both as to individuals and species, and bogs which form during the winter and dry up in the summer should be avoided; they are seldom remunerative. Moorland pools are always worth the collector's attention, and often yield quite different species from those of the bogs. A feature that strikes one in connection with them is that often they are occupied almost exclusively by one, or at most a very few, species. One moorland pool examined on Dartmoor was so filled with *Staurastrum brachiatum* that from every part of it the net was crowded with specimens, and another small pool was quite green with the rod-like threads of *Hyalotheca dissiliens*, and

practically nothing else occurred there. Yet another pool was the exclusive preserve of *Xanthidium variabile.*

The paper was greatly appreciated for its practical and useful character, and at its conclusion considerable discussion took place, in which Messrs. Wilson, Scourfield, Brown, Gabb, and others joined. Mr. Burton, who had had some experience in mounting desmids, while admiring greatly the perfection with which Mr. Harris had preserved the natural colour of his specimens, expressed a preference for staining methods which, if successful, differentiated the tissues more distinctly than the other. At its very best the natural colour could only be retained in the chloroplast, where alone it existed, leaving the rest of the specimen undifferentiated. He also feared as to the lasting powers of mounts in somewhat deep cells where the medium was practically water only, which always sooner or later acted on the cement. In his own mounts, which were in glycerine, he endeavoured to employ as dense a fluid as it was possible to use without contracting the protoplasm. A hearty vote of thanks was passed to Mr. Harris for his interesting and useful paper. A number of specimens of desmids mounted by Mr. Harris in the way described were exhibited under microscopes on the table, and were greatly admired, especially for the beautiful way in which the natural colour was preserved.

At the 514th Ordinary Meeting, which was also the fiftieth Annual Meeting, held on February 22nd, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on January 25th were read and confirmed.

Messrs. Charles H. Bocock and J. J. Jackson were balloted for and duly elected members of the Club.

A series of micro. objects were exhibited by Mr. W. E. Watson Baker to illustrate the results of some new mounting methods. In view of the President's recent addresses on sponge spicules, three specimens, viz.: A type slide of sponge spicules, a group of sponge spicules from St. Peter, Hungary, and a section of *Euplectella mirabilis* were exhibited. The first two are rather rare, the mounter having died some years ago, and no one having taken up the work since. A slide of an unusually perfect specimen of *Filaria nocturna*, stained with Giemsa and mounted in neutral balsam, which displayed the details of the object remarkably

distinctly, was shown. There were three slides of test diatoms, *Pleurosigma sinense* and *Nitzschia rabenhorstii* to illustrate a new arrangement in which the longitudinal and transverse striae of each specimen are counted and marked on the slide. By this means it is hoped to standardise the use of these objects for testing objectives. Another was a type slide of sixty-four specimens from a deposit at Atlantic City, New Jersey. It had been found that specimens of the same species from different localities showed a variation in the fineness of the markings. In order, therefore, to get a record of any variations from these localities, a series of slides was being collected and mounted, which it was hoped would be of particular value to diatomists. Mr. Baker stated that, since the death of Mr. Elcock, of Belfast, he did not know of any professional mounter of Foraminifera type-slides except Thum, of Leipzig. Recently, however, an English mounter had taken up this work, and two of his slides, one of thirteen and the other of thirty-two species, were exhibited. These were much admired for the perfection and cleanness of the specimens. The special mount in which they were put up allowed them to be taken out for photographic use, and they could be examined without a cover-glass, thus overcoming entirely the reflection from the cover which is so often troublesome. At the suggestion of the President, a hearty vote of thanks was accorded to Mr. Watson Baker for his exhibit and interesting remarks respecting the specimens.

The special business of an annual meeting was then proceeded with. The President requested two members to act as scrutineers, and the ballot was taken for the officers, and to complete the number of the Committee after the annual retirement. The result was announced later, as far as possible those appointed being the same as previously. The Hon. Sec. read the Committee's report, which disclosed a very satisfactory condition notwithstanding the many difficulties caused by the war. In spite of the darkened streets, the restricted means of conveyance, and the large number of the younger members engaged in military matters, the attendance at the meetings was only slightly less, while there was even a small increase in the list of members. The reports of the Librarian, the Secretary of the Excursions Sub-Committee, and the Curator were all good. The Treasurer's balance-sheet, though obviously affected adversely by the war,

and by some unusual expenses, was perfectly satisfactory. These were all adopted and passed by the meeting.

After requesting Vice-President D. J. Scourfield to take the chair for the occasion, the President then delivered his annual address, which was entitled "Some Factors of Evolution in Sponges." It dealt largely with the development of the spicules in the various classes of sponges, and necessarily was of a distinctly technical character. At its conclusion the Chairman, after some comments on the value and interest of the address, requested the President to allow it to be printed in the *Journal*, and proposed a vote of thanks to him. This was accorded by acclamation by those present. Prof. Dendy cordially gave his consent to the request, and resumed the chairmanship of the meeting. A vote of thanks to the scrutineers of the ballot and to the auditors of the balance-sheet was proposed and carried; as was also the same to the Officers and Committee, with some appreciative remarks on the care and hard work that must have been requisite to produce such satisfactory results during the difficult period of last year. The Treasurer, Mr. F. J. Perks, made an appropriate reply.

The President then read out the result of the ballot for Officers for the ensuing year:

As President . .	Prof. Arthur Dendy, D.Sc., F.R.S.
As Four Vice-Presidents.	C. F. Rousselet, F.R.M.S. D. J. Scourfield, F.Z.S., F.R.M.S. E. J. Spitta., L.R.C.P., M.R.C.S., F.R.A.S. David Bryce.
As Treasurer . .	Frederick J. Perks.
,, *Secretary* . . .	James Burton.
,, *Foreign Secretary*	C. F. Rousselet, F.R.M.S.
,, *Reporter* . . .	R. T. Lewis, F.R.M.S.
,, *Librarian* . .	S. C. Akehurst, F.R.M.S.
,, *Curator* . . .	C. J. Sidwell, F.R.M.S.
,, *Editor* . . .	A. W. Sheppard, F.Z.S., F.R.M.S.
As Five Members of Committee.	C. D. Soar, F.L.S., F.R.M.S. R. Paulson, F.L.S., F.R.M.S. G. H. Gabb, F.C.S. M. A. Ainslie, R.N., B.A., F.R.A.S. Jas. Grundy, F.R.M.S.

FIFTIETH ANNUAL REPORT.

Your Committee in making their Report for the year ending December 1915 may be allowed to remind members of the many difficulties and drawbacks that have been encountered owing to the continuance of the war. Taking these into consideration, they feel justified in congratulating the Club on the results which have been achieved. Twenty-three new members have been elected, sixteen have resigned, and five have been lost through death, giving a net increase of two, and a total membership of 449. The number elected and the total increase are considerably below those of recent years, but nothing else could be anticipated in the circumstances.

Having regard to the darkness of the streets, the lessened means of conveyance, and the quite reasonable reluctance of many to be absent from home after dark, owing to the possibility of air raids, and also to the fact that a considerable number of members are at the front, or engaged on Government work, it might have been expected that the attendance at the meetings would be seriously affected; and it is most encouraging to find, on comparing the numbers present during the past year with those of 1913, that the reduction in numbers attending the Ordinary Meetings has amounted to an average of eight only; and the attendance on the Gossip nights has been an average of only six less than in 1913.

The Club has to deplore the death of Past-President Prof. E. A. Minchin. His last lecture was given in January, and was accompanied by a gift of mounted specimens. He was present at the Annual Meeting in February, and took the chair while Prof. Dendy delivered his Presidential Address; this was his last evening with us. An obituary notice and portrait appeared in the *Journal* for November.

In February the death of Mr. F. W. Millett took place. He was one of the original members, having joined in July 1865. Owing

to his residence in Cornwall and his advanced age (he was in his eighty-second year at the time of his death), he had not been able to attend the meetings for a long time. An obituary notice appeared in the April number of this *Journal.* In June the death of Mr. G. Vogeler occurred; he had been an active member of great assistance, especially in the Curator's department. A former member, Mr. B. W. Priest, died in September; he had not been to the meetings for many years, but with a kindly remembrance has bequeathed a collection of sponge preparations to the Club.

The papers and exhibits during the year were as follows:

Papers and Exhibits during 1915.

January 26th.—Prof. E. A. Minchin: Notes on the Anatomy of the Rat Flea—*Ceratophyllus fasciatus.*

February 23rd.—The President: The Biological Conception of Individuality.

March 23rd.—C. D. Soar: British Hydracarina—Genus *Lebertia.*

March 23rd.—J. W. Gordon: A "New" Object-glass by Zeiss.

March 23rd.—G. T. Harris: Microscopical Methods in Bryological Work.

April 27th.—M. A. Ainslie: An Addition to the Objective.

April 27th.—A. A. C. Eliot Merlin: Notes on Diatom Structure.

May 25th.—J. Grundy: Exhibit—A Fly's Wing, showing crystals formed in the mountant.

May 25th.—A. E. Hilton: Further Notes on the Cultivation of *Badhamia utricularis.*

May 25th.—E. M. Nelson: Various Insect Structures.

May 25th.—J. Burton: *Hydrodictyon utriculatum.*

May 25th.—Seabury Edwards: On mounting Diatoms in Phosphorus.

June 22nd.—Dr. John W. Evans: The Microscopical Examination of Minerals.

October 26th.—A. E. Hilton: The Formation of Sporangia in *Stemonitis.*

October 26th.—D. Bryce: Five New Species of Bdelloid Rotifers.

November 23rd.—W. R. Traviss: Exhibit—A Binocular Addition to Swift's Portable Binocular.

November 23rd.—The President: On Sponges, General Structure, and Spicules.

December 28th.—J. T. Cook: Exhibit—A New Form of Trough for Pond Life.

December 28th.—J. Burton: Notes on a Species of *Aleurodes.*

Your Committee wishes to thank the authors on behalf of the members for these interesting communications.

The Fiftieth Anniversary of the foundation of the Club occurred in June. It had been intended to mark the event by some celebration, but it was felt by many that in the circumstances of the war such a course would not be appropriate. The President at the Ordinary Meeting on the 22nd, however, called the attention of the members to the event; a full account of the proceedings appears in the *Journal* for November. In November the President gave an address on Sponges—the first of a series of short addresses which he is kind enough to propose to deliver at intervals during the session. Material for distribution, that the members might follow out the subject by making their own preparations, was also provided by Professor Dendy. The Gossip Meetings have not only been well attended, but there has been almost no diminution in the number of objects of interest exhibited, and in the enthusiasm of those displaying and explaining them. The Committee thank those who, often at considerable personal trouble, have done so much to render these meetings a success; and would press upon all those able to do so the desirability of their taking part in the good work.

The new catalogue of the Library issued to the members in 1915 has no doubt helped to maintain and increase an interest in the Library, with the result that 160 volumes have been issued to the London members, during the year. The arrangements made to post books to country members have not been taken advantage of, only one application having been received since the scheme came into force. To give members an opportunity of ready access to those books, available for reference only, a selection of such works has been placed on the table on Gossip nights for examination, and this arrangement, which has been much appreciated, will be continued in the future.

List of Books Purchased and Presented from January 1915 to January 1916.

Purchased.

A Monograph of the British Marine Annelids. By Prof. W. C. McIntosh. Vol. iii., pt. 1. Text. Polychaeta. Apheliidae to Ammocharidae. 1915.

Icones Plantarum Asiaticarum, Part I. 1847.

Handbook of Photomicrography. By H. Lloyd Hind and W. Brough Randles, 1913.

Presented.

Les Diatomées du Monde entier. By J. Tempère and H. Peragallo, 2nd ed., 1915.

American Hydroids. By C. C. Nutting. (Smithsonian Institute. Special Bulletin.)

Miscellaneous Papers on Rotifera. By C. F. Rousselet.

Reports of the Clare Island Survey, *Proceedings of the Royal Irish Academy*, vol. xxxi.

Elementary Photomicrography. By W. Bagshaw, 3rd ed., 1915.

Contributions à l'étude des Rotateurs du Bassin du Léman. By G. Montel.

List of Periodical Publications Received for the Year ending December 1915.

Academy of Natural Science, Philadelphia.
American Microscopical Society.
Bergen Museum.
Botanical Society of Edinburgh, Proceedings and Transactions of.
California, University of.
Geologists' Association, Proceedings of.
Glasgow Natural History Society.
Hertfordshire Natural History Society, Trans. of.
Indian Museum, Calcutta.
Manchester Literary and Philosophical Society.
Manchester Microscopical Society, Trans. of.
Micrology, The Journal of.
Microscopical Science, Quarterly Journal of.

Missouri Botanic Garden.
Nyt Magazine.
Philippine Journal of Science.
Redia.
Royal Institution of Great Britain, Proceedings of.
Royal Microscopical Society, Journal of.
Royal Society of London, Proceedings of. B Series.
Royal Society of New South Wales.
Smithsonian Institute.
Victorian Naturalist.
Wisconsin Academy.

During the year twelve excursions were held, the average attendance was 17·6; this is very good when the number of our members serving their country abroad or at home is taken into consideration. The difficulty of finding suitable localities for the Saturday afternoon excursions was increased by some curtailment of excursion trains, as well as by the fact that owing to war conditions it was not possible to visit the East London Water Works or the Surrey Commercial Docks. The excursion to Northolt and Ealing under the guidance of Mr. Offord was highly successful, and a very pleasant outing was brought to a close by the kindness of Mr. and Mrs. Offord in entertaining the members to tea at their house. We were indebted again to Sir Philip Sassoon for permission to visit the private waters in Trent Park, and to the Royal Botanic Society for their usual kindness in allowing us to visit the gardens in Regent's Park.

The Curator reports that a larger number of slides has been lent than during the previous year, and 173 preparations have been added to the Cabinet. The principal of these are twenty-four beautiful and instructive dissections of the Rat Flea, kindly given by the late Prof. Minchin, which, in conjunction with a reprint of his paper, are available for borrowing as one of the descriptive series. A welcome addition was the donation of seventy-seven slides of Mosses from Mr. G. T. Harris, which should prove valuable to any member taking up the study of this interesting family. Another addition has been the purchase of a type-collection of forty slides of Palaeobotany, prepared by the well-known expert, Mr. Lomax. These are remarkably fine specimens, and the majority of them are described and illustrated in

Dr. Scott's *Studies in Fossil Botany*, a copy of which work is in the Club's Library. The gift by Mr. Huish of a small set of preparations of Mycetozoa has also filled a gap in the cabinets. The Committee tenders its best thanks to Mr. Bestow for the assistance he has given to the Curator in the issue of slides and the work of the Cabinet, and to Mr. Todd, who as Assistant Librarian has been full of energy in the work of the department. Also to Mr. L. C. Bennett, who has been of the greatest service in making visitors welcome and in introducing them and those newly elected to the other members, and in thus promoting the social spirit and friendliness for which the Club has always been notable. Thanks are due to Mr. Robotham, who as Assistant Secretary has supplied excellent reports of the meetings to the *English Mechanic* on many occasions.

The Committee wishes once again to express their thanks, and those of the general body of members, to the various officers for their care and often hard work in conducting the affairs of the Club with such efficiency during the trying period of last year.

Finally, they would call upon all if possible to increase their efforts for continued success, by attending the meetings as often as they can, by bringing a microscope with objects for exhibition whenever possible; and especially by making a communication and taking part in any discussion at the Ordinary Meetings, and by introducing the Club to the notice of anyone among their friends who is likely to join it.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1915.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1915	171	15	6	By Rent	75	0	0
,, Subscriptions	182	10	0	,, Expenses of *Journal*	103	14	7
,, Dividends on Investments	15	8	0	,, Postages, etc.	5	6	6
,, Sales of Journal	0	16	6	,, Printing and Stationery	9	4	5
,, Advertisements	13	10	0	,, Attendant	6	1	5
				,, Petty Expenses	1	14	0
				,, Books	9	13	3
				,, Slides	5	12	6
				,, Catalogues (Library)	47	16	3
				,, *English Mechanic*	6	13	8
				,, Balance in hand	113	3	5
	£384	0	0		£384	0	0

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

February 8th, 1916.

J. WILSON
WILFRED E. WATSON BAKER } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

THE LATE RICHARD THOMAS LEWIS, F.R.M.S.

(aetat. 54.)

Frontispiece] [See page 201

THE SECONDARIES OR DOTTED STRUCTURE IN PINNULARIAE.

By Chapman Jones.

(*Read April 25th,* 1916.)

Communicated by A. Morley Jones.

Plate 7.

About forty-five years ago Mr. Henry J. Slack contributed a note to the Royal Microscopical Society * in which he remarks that "at one time it was supposed that the Pinnulariae were distinguished from allied forms by solid costae replacing beaded bands," but "more recently this distinction has not been deemed valid." He continues that "an examination of the Pinnulariae on Möller's type-slide led to the belief . . . that instead of broad irresolvable ribs, a truer view" of the costae "exhibited fine lines of beads springing from the median band, with a furrow between them, and in that furrow another line of beads at a lower level." Mr. Slack obtained from Möller a series of Pinnulariae mounted dry, and examined them by means of "a remarkably fine immersion 1/8th by Powell & Lealand on their new system. The condenser employed is a 4/10th one of Ross, and the usual stop, one radial slot, aperture 109°. The most serviceable eyepieces were C and D of Ross's scale." The twelve species examined all showed, though some with much difficulty, "the composite character of the so-called costae."

Quite recently, Mr. T. A. O'Donohoe † has produced a photograph of a *Pinnularia nobilis* which shows excellently the presence of a dotted structure. He used annular illumination and a 2 mm. apochromat. But in spite of these results, and perhaps

* *The Monthly Microscopical Journal,* xxxii., August 1871, p. 71.

† *Journal of the Quekett Microscopical Club,* April 1914, p. 309.

other work on this subject, the nature of the dotted structure and the reason for its elusive character do not appear to be known. Having among my slides of Pinnulariae one in which the valves have suffered much both mechanically and from corrosion (I suppose in cleaning the material) I have searched for information on these points.

I think that the photographs that I have the honour of laying before the Club, as well as the examination of many other specimens on other slides as well as this particular one, lead to the following conclusions :

1. That finding the dots is not a matter of resolution as ordinarily understood, but rather of rendering them more conspicuous, except perhaps in some of the smaller valves. The dots in Mr. O'Donohoe's photograph are of about the same order of coarseness as those of *Surirella gemma*, and this diatom cannot be called a very difficult one to resolve. I have measured them as well as I can from the reproduction of his photograph and find that their distance apart is equivalent to from 60 to 70 thousand to the inch. The dots in the specimens I have examined are not uniformly distanced in any one case. In figure No. 1, which represents a part of a large valve, they range from 32 to 40 thousand to the inch ; in figure No. 2, which is a rather small valve, 50 to 70 thousand to the inch ; in the other figures from 43 to 46 thousand. High-power dry objectives of ordinary apertures have therefore quite sufficient "resolving" power.

2. That the dots are not immediately connected with the costae as Mr. Slack and others appear to have assumed.

3. When viewing a valve in the ordinary way, that is, with its outside or convex side uppermost, it appears that there is a dotted membrane under the costae, and a non-dotted if not structureless membrane over the costae, and that the dots are generally hidden by this upper membrane, unless special means are taken to render the dots conspicuous.

4. This dotted membrane appears to be attached, at least in some cases, to the girdle. This accounts for its absence from some valves. On the other hand, it is sometimes attached to the costae. Perhaps there is a strip of dotted membrane attached

to or forming a part of the girdle, and other dotted membranes attached to the costae, but I have no direct evidence of this.

5. That the dots are concavities, as one might expect by analogy, because fracture takes place across them, and when seen sideways on the rounded edge of a curved membrane the curve of the concave outline is obvious.

The photographs were all taken with a 2 mm. Holos. objective, N.A. 1·36; × 8 compensating eyepiece; a Holos. immersion condenser diaphragmed down to N.A. 1·0, except for oblique light, then at full aperture of N.A. 1·38; and with green light. The specimens are mounted in "realgar."

Fig. 1. *Pinnularia nobilis*, × 1,300. Illuminated with a solid, central cone N.A. 1·0. This shows dots through the costae and along the whole length of each costa as far as the focus allows. There is also evidence of out-of-focus structure between the costae.

Fig. 2. *P. nobilis*, × 1,200. A much smaller valve than above, and one that shows no trace of structure with central light. A is focused for a slightly lower plane than B. Doubly oblique light. The dots are clearly visible along the whole length of the costae, as the focus permits, and also between them. The dots are veiled, I suggest by the membrane that lies over the costae, and to a certain extent confused by the material that they have to be seen through.

Fig. 3. *P. viridis*, × 1,280. Illuminated with a solid central cone, N.A. 1·0. The upper membrane here is missing in parts, and where it is missing the dots show through the costae and also between them.

Fig. 4. Part of a valve with its inner or concave surface uppermost, × 1,250. Illuminated with a solid central cone, N.A. 1·0. Portions of dotted membrane are adhering to the upper (really the inner as regards the frustule) edges of the costae.

Fig. 5. These appear to be detached costae showing their side faces, × 1,250. Illuminated with a solid central cone, N.A. 1·0. They show no sign of dotted structure.

Fig. 6. A detached strip of dotted structure, × 1,200. Illuminated with a solid central cone, N.A. 1·0. The whole length of the strip, only part of which is shown, agrees with the length of

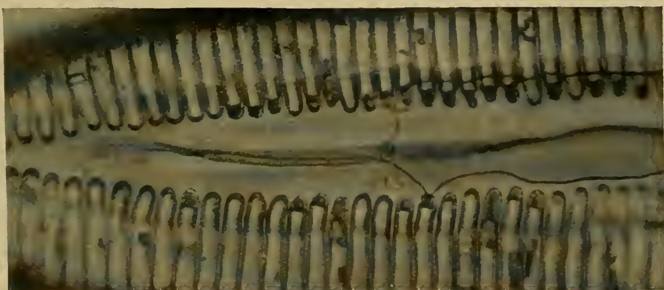
the Pinnulariae near it, and I do not find anything else on the slide of which it might be a part.

A seventh photograph was exhibited, showing a girdle, × 1,250. Illuminated with a solid central cone, N.A. 1·0. The dotted membrane at the margin of the girdle is curved round to approximately a right angle to the face of the girdle, so that this might project into the frustule and thus lie under the costae. Girdles like this are not rare.


1


2A


2B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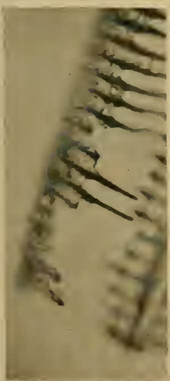
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5


6

THE SECONDARIES OF PINNULARIAE.

ON *NITZSCHIA SINGALENSIS* AS A TEST-OBJECT FOR THE HIGHEST POWERS.

By A. A. C. Eliot Merlin, F.R.M.S.

(*Read April 25th*, 1916.)

Plate 8.

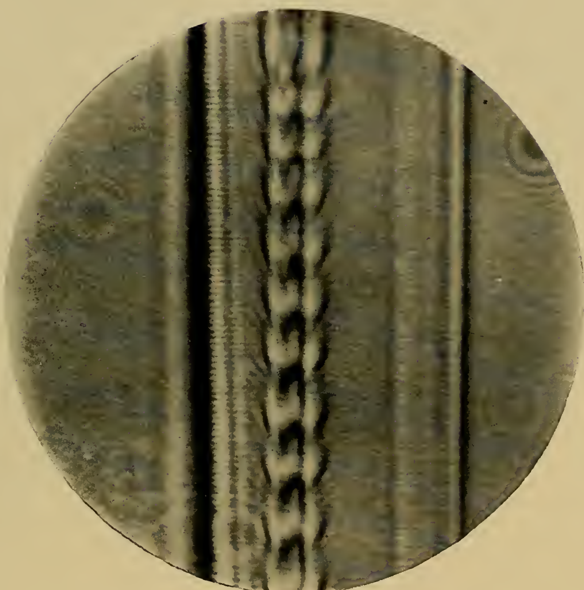
I am indebted to the kindness of my friend Mr. E. M. Nelson for a styrax mount of this very interesting diatom from Amherst, Burma. Its minute structure is undoubtedly of a similar nature to that of other and coarser varieties of the genus, but although the form is large, the structure is so fine that hitherto only the transverse striae have been seen by their discoverer, Mr. Nelson, and up to the present most other microscopists have failed to see them. Under these circumstances the photograph (Pl. 8) taken with a 1/8th apochromat of 1·42 N.A. at a magnification of 3,600 diameters by means of oblique sunlight from a heliostat, which clearly reveals the transverse striation, will, I venture to think, prove of interest to many members of our Club, which has done so much in the past in an unpretentious way to encourage advancement in all matters appertaining to the microscope.

At present many of us must feel that our old friend *Amphipleura pellucida* can no longer claim the proud position which it so long held as *the* test for objectives of the highest power. As a matter of fact, for many years past, any tolerable oil-immersion lens of moderate aperture could be relied upon to reveal easily its once elusive transverse striae (which run at from 93,000 to 100,000 to the inch) by means of oblique light. Really good objectives of 1·3 N.A. will reveal them in balsam without any great difficulty with axial illumination, and I have photographed clearly striae at 95,000 to the inch in a realgar preparation of *A. pellucida* with central light from the edge of the lamp flame.

Thus the conscientious microscopist can no longer feel that he is accomplishing anything requiring great manipulative skill when he obtains distinct rendering of the transverse striae of an average *A. pellucida*, although of course to show the dotted structure is a far more difficult task.

With the *Nitzschia singalensis* the case is different, and any microscopist who can clearly reveal the transverse striation may justly feel satisfied with his optical appliances. I endeavoured to count visually the striae by "stepping" with the cobweb micrometer in the usual way, and noted 116,000 to the inch as the result, but owing to their faintness the eye became rapidly fatigued, and I could not feel any great confidence in the accuracy of the count. Another and more certain method is available, and the magnification at which the photograph (Pl. 8) was taken was verified as exactly 3,600 diameters by the projection of Grayson's rulings on to the camera screen with the precise optical combination and camera extension used to obtain the photograph. Now the striae on the photograph run at 32 to the inch, which multiplied by 3,600 makes them 115,200 to the inch. This may be relied upon as correct for the specimen photographed.

In practice I have found that the transverse striae of *N. singalensis* can be revealed with a good semi-apochromatic objective of 1·33 N.A. by means of axial light and a Gifford screen; and I should here like to record my conviction, as the result of long experience, that a really well corrected and fine objective will resolve fully as much with axial as with oblique light, although it may need less skill and less keen sight when employing the latter method. I also venture to suggest that, as a test for first-rate objectives of the largest aperture, *Nitzschia singalensis* must henceforth rank far above *A. pellucida*, and any failure to resolve the transverse striae of the former with lenses of 1·30 N.A. and upwards will indicate a faulty objective or faulty manipulation. Nevertheless, the test is severe, and when accomplished with axial light requires good eyesight in addition to good optical means.



Nitzschia singalensis.

NITZSCHIA SINGALENSIS: A NOTE ON MR. MERLIN'S PAPER.

By M. A. Ainslie, R.N., B.A., F.R.A.S.

(*Read April 25th*, 1916.)

It has long been recognised that as a test for resolution, at any rate with oblique light, our old friend *Amphipleura pellucida* leaves something to be desired; as Mr. Merlin says, the exhibition of its transverse striae is no great feat at the present day.

I am inclined, however, to think that no resolution, even of the most difficult diatom, when performed by means of oblique light, affords any real criterion of the excellence of an objective; indeed, I have heard it whispered that at one time it was not an uncommon practice with some opticians to correct their immersion objectives to give the best possible resolution with oblique light, without much attention being paid to the correction of the central and intermediate zones, which would be more useful for general purposes. So long as their customers were desirous of possessing objectives "which will resolve *A. pellucida*," and regarded the performance of this feat as the principal duty of an immersion objective, it was natural that opticians should make every effort to gratify their wishes. I have myself obtained excellent resolution of the transverse striae, at any rate, of *A. pellucida*, with objectives which were practically useless for ordinary purposes, such as the examination of Bacteria, etc.

Something better is required at the present time; and until we have, as is much to be desired, specimens of *N. singalensis* mounted in realgar, I am inclined to think that the resolution of the transverse striae of *A. pellucida* in this medium, with a *full* solid axial cone of illumination, remains the best existing test of the all-round capacities of an oil-immersion objective; at any rate, in the course of the examination of a great number of

different objectives by various makers, I have always found that a good, clear exhibition of these striae under the conditions indicated was a sufficient guarantee of the excellence of the objective for all-round work.

I do not forget, of course, that Mr. Merlin records that he can see the transverse striae, both of *N. singalensis* and of *A. pellucida*, with axial illumination; in the latter case when mounted in balsam. This appears to me to prove that Mr. Merlin is blessed with a keenness of eyesight far above the average; I have looked in vain for the slightest trace of the striae under these conditions, and even in the case of *A. pellucida* the utmost I have been able to do with axial illumination is to see the transverse striae faintly, but certainly, in monobromide of naphthalin, with an apochromat of N.A. 1·40, and with a fluorite objective of N.A. 1·34. I do not, of course, claim that my own eyesight is in any way remarkable; indeed, in the matter of the detection of fine dark lines on a bright background—which is here in question—I have reason to believe that my sight is not particularly keen. I am strongly of opinion, however, that this test is, for the great majority of observers, much too severe, and probably too severe also for the great majority of objectives.

Mr. Merlin's opinion as to the resolving power of objectives with axial light as compared with oblique is certainly in accordance with theory; but even with the very best objectives obtainable I have frequently found that I could, with oblique light, detect striae which were wholly invisible with axial illumination.

There is one point in Mr. Merlin's paper which leaves me a little puzzled: he refers to the difficulty he experienced in "stepping" the striae on *N. singalensis*, owing to their faintness, while on the other hand he sees them with axial light. As far as my experience goes, if diatom striae are visible at all with axial light there is never any great difficulty in measuring them with oblique; I have measured the striae on *A. pellucida* in balsam, although in this medium they are, to me, wholly invisible with axial light, without any special difficulty due to their faintness.

I am showing the transverse striae on *N. singalensis*, resolved with a Leitz 1/10th oil-immersion of N.A. (measured) 1·33, not only because they are of interest in themselves, in connection with Mr. Merlin's valuable paper, but because it so happens that they afford an excellent example of the occasional utility of a device

which, though known for many years past, has never received any very great attention from microscopists; I refer to the enhancement of the resolution by the introduction of an analysing Nicol prism into the path of the rays; in this case, for convenience, between the eyepiece and the objective, although its effect is apparently the same wherever it is placed. Without this device, I have been unable to see the striae, even with the greatest possible obliquity in the incident light, with a flame-edge in use; I have seen them faintly, but certainly, with a gas-mantle and strongly with a Nernst lamp; but the effect of the introduction of the analyser is, in the present case, most striking; the resolution is perfectly plain with any illuminant in use, and there is not the smallest difficulty (due to their faintness) in measuring them; the result, in the case of the specimen shown, being 115,000 to the inch.

The light diffracted by diatom striae is found to be partially polarised, to an extent depending (according to Mr. Conrady) on the nature of the structure, and on the angle between the incident and diffracted beams—that is to say, on the fineness of the striation; and it is by no means with all such objects that the effect is noticeable. The same authority points out that the fact of the diffracted beam being polarised proves that the object cannot be considered to behave as if it were self-luminous, as is claimed by some of the opponents of the Abbe theory of microscopic vision. Probably the effect of the polarisation in enhancing the visibility of the striae, in cases where resolution occurs, is due partly to the reduction in the intensity of the direct beam, the diffracted beam being little, if at all, affected; and partly, no doubt, to some relation between the planes of vibration of the light-waves in the two beams. The prism is placed with its longer dimension parallel to the length of the valve, and at right angles to the striae; and although, as said above, the effect is by no means invariable, I think this device is at all times worthy of trial in the case of difficult resolutions.

In effecting difficult resolutions such as the case under consideration, it seems necessary to have an illuminant of considerable intrinsic brilliancy; *i.e.* very bright in proportion to its size; and the beam of light directed on the object should be as narrow as possible, and at the extreme margin of the back lens of the objective. A Nernst lamp gives an excellent result, and

even the little "flash-lamp" does admirably, on account of its presenting a very small area of intense brilliancy; but the edge of a flame, although its total light may be greater, has much less intrinsic brilliancy.

Though I understand that the resolution of *N. singalensis* has been effected by means of the light from a flame-edge, both by Mr. Merlin and Mr. Nelson, I should like to warn any microscopist who sets out to see these striae with this form of illumination, and without the addition of the analysing prism, that he is quite likely to be disappointed.

AN HISTORICAL ACCOUNT OF THE PSEUDOSCORPION-FAUNA OF THE BRITISH ISLANDS.

By H. Wallis Kew.

(*Read June 27th*, 1916.)

Figs. 1–2.

The False-Scorpions are almost world-wide in distribution and one may be sure that they have been known to man almost everywhere in all ages. But records of such knowledge, preserved and accessible to us, are scarce until comparatively recent times; and indeed they do not become numerous until within the life-time of men now living. There are two references to these creatures in the works known to us as the Histories of Animals of Aristotle which have undoubtedly come down from what we regard as a remote age. The animals are there stated to be found in books. Next, towards the renaissance of the sciences, there is a mention of them by Scaliger, in 1557, who gives for them the same habitat, and tells us that he found one in Aristotle's book itself. After this, if we pass over a restatement of Aristotle and Scaliger by Aldrovandi, in 1602, there is nothing antedating the work of Hooke, with which the present account commences. The Royal Society's order for the printing of this work is dated November 23rd, 1664, and the book was on sale before the then end of that year.* It contains the first detailed description and the first figure of any animal of this Order.

* Cf. Pepys; January 20th, 166 $\frac{4}{5}$: "To my bookseller's, and there took home Hook's book of microscopy, a most excellent piece. ." The date on the book itself is 1665.

1. Hooke, R.—Micrographia: or some Physiological Descriptions of Minute Bodies made by Magnifying Glasses. London, 1665.

Hooke writes of a "Crab-like Insect." He saw it walking on a book he was reading; and, having a microscope by him, lost no time in making a description and drawing of it (fig. 1). No locality is mentioned, but from what we know of Hooke, it was

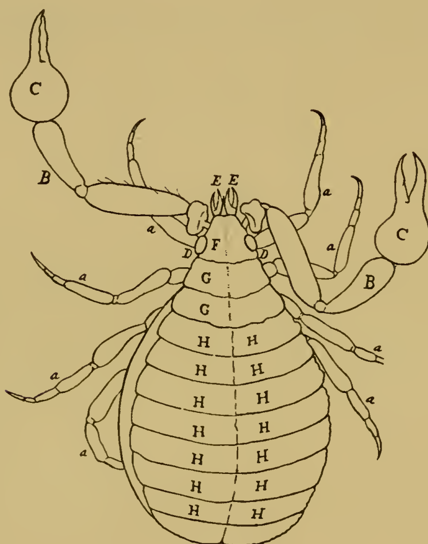


FIG. 1.

Reduced outline of the "Crab-like Insect" of Hooke (1), pl. xxxiii. fig. 2. [=*Cheiridium museorum* (Leach)].

certainly in England, and presumably in London, that the observation was made. He relates, amongst other things, that the creature had ten legs, eight of which, AAAA, were those on which it walked; and the other two, BB, which were the foremost, were formed in the manner of crabs' claws, the ends of them being furnished with a pair of pincers, CC, which the animal did open and shut at pleasure; nor did it want other hands, having another pair of claws, EE, very near placed to its mouth, and

seemed adjoining to it; etc. (cf. fig. 2) = **Cheiridium museorum** (Leach, 1817).*

The next detailed account and figure are those of "Die Scorpion-Spinne" of Frisch's "Beschreibung von allerley Insecten in Teutsch-Land," viii., published in Berlin, in 1730. Linnaeus' "Systema Naturæ" appeared in 1735, at Leyden, and contained a citation of one of these animals: "Scorpio-Araneus" (under *Acarus*).

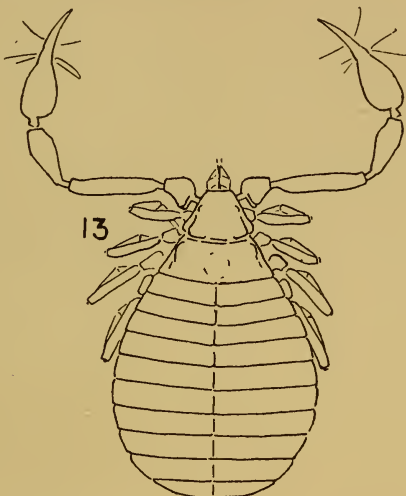


FIG. 2.

Cheiridium museorum (Leach). From Kew (**38**), pl. v. fig. 13.

2. Albin, E.—A Natural History of Spiders and other Curious Insects. London, 1736.

Among the "Spiders" illustrated is one, which was found amongst some books, and had "in the place of feelers two long things like the claws of a lobster." = *Chelifer* sp.

* The present paper is not a bibliography of British Pseudoscorpiones; but, among the books and papers cited, are all those which, following Hooke (**1**), make additions to this part of our fauna; and, interposed in smaller type, are references to further works which, with many others, occupy important positions in the general literature of the Order.

Linnaeus' "Systema Naturæ" ed. x. appeared at Stockholm in 1758–9; and contained two false-scorpions: *Acarus cancroides* (Europe) and *Acarus scorpioides* (America). In ed. xii., Stockholm, 1766–8, these species were transferred to *Phalangium* and the name of the second was changed to *acaroides*. Linnaeus ignored *Chelifer*, which had been proposed in Paris, by Geoffroy, in 1762; and it was not till 1785 that Fourcroy, also in Paris, first used the familiar combination *Chelifer cancroides*.

3. Martin, B.—The Young Gentleman and Lady's Philosophy, iii. London, 1782.

Contains a long account in dialogue-form, and a grotesque figure, of a "Lobster Insect," found by some labouring men in a public-house, and borne away by an ingenious gentleman, from whom the author borrowed it. = *Chelifer* sp.

4. Adams, G.—Essays on the Microscope. London, 1787.

From this book it appears that the public-house above referred to was at Waltham Abbey; and the gentleman who bore away the specimen was John Adams of Edmonton. From him it passed to the author under notice, whose new figure of it resembles in some respects *Chelifer* (*Chernes*) *nodosus* Schr., 1803. The author tells us, moreover, of another specimen, in the possession of Mr. Marsham, who found it fixed by its claws to the thighs of a fly, which he caught on a flower in Essex. This is the first record, in these Islands, of the clinging of false-scorpions to flies' legs, the first known and only earlier one being in Poda's "Insecta Musei Græcensis" (Grätz, 1761).

5. Shaw, G.—The Naturalist's Miscellany, iii. London, 1791.

Contains a figure of "*Phalangium cancroides*." = *Cheiridium museorum* (Leach, 1817).

6. Donovan, E.—The Natural History of British Insects, vi. London, 1797.

Among the finely engraved and beautifully coloured plates of this work is one of "*Phalangium cancroides*" which is stated to be the largest insect of the genus found in England that resembles a scorpion. = **Chelifer cancroides** (Linn.).

7. Kanmacher, F.—*In* Adams, G.—Essays on the Microscope, ed. 2. London, 1798.

F. Kanmacher, who edited this edition of Adams (**4**), was acquainted with several of these animals. He refers to one

found on a bottle of wine in saw-dust in a cellar in Percy Street [London], and to another found by a botanist among some plants. And he had lately seen another, in which the two fangs [chelicerae] were very apparent, being so large as to exceed in diameter the thickest part of the claws [palps]. This is *Chthonius* sp.; and is a very early reference to a false-scorpion of that kind. The only earlier one is by Preyssler who established *Scorpio tetrachelatus* [*Chthonius tetrachelatus*] in his "Verzeichniss böhmischer Insekten" (Prague, 1790).

The celebrated "Mémoire Aptérologique" of Hermann (who had died in 1794 at the age of 25) appeared in 1804 at Strasbourg, and contained the first methodical account of a series of these animals. Six species (from the local fauna), studied with ample magnification, were ably described and figured; and *Chelifer* (to which they were referred) was divided into two sections, which foreshadow the two main divisions of the Order—Panctenodactyli and Hemictenodactyli—of modern authors.

8. Montagu, G.—Descriptions of several new or rare Animals, principally marine, discovered on the South Coast of Devonshire. Trans. Linnean Society, xi. pp. 1–26. London, 1813.

In this memoir, which Montagu had presented to the Society in 1807, the false-scorpions are retained in *Phalangium*. *Chelifer* had been "very properly instituted," but it had been thought proper, in that place, to affix to these insects the titles by which they were generally known.* "*Phalangium cancroides*" is employed as the name of a small species, = *Cheiridium museorum* (Leach, 1817), which the author was accustomed to see in one of his cases of preserved birds. His principal object, however, was to make known similar animals of another sort. Of these he had two kinds or more; but they are referred together, with a mark of doubt, to "*Phalangium acaroides*." The one which concerns us here (of which a figure is given) was from

* Sir J. E. Smith, purchaser of Linnaeus' collections and institutor of the Society, was still President, and others supposed to be bigoted to the system of Linnaeus were prominent in the Society's concerns. A spirit of restraint was, no doubt, rife at this time; but it has been exaggerated. Montagu, in any case, would be a willing co-operator, being himself mistrustful, as we learn elsewhere, of attempts to improve on the Linnaean plan.

Cornwall, taken on rocks contiguous to the sea. = **Obisium maritimum** Leach, 1817.

9. Leach, W. E.—Crustaceology. *In* Brewster's Edinburgh Encyclopædia, vii. pp. 383–437. Edinburgh [1814 ?].

This is the first of several contributions to our subject by Leach—less than 25 years of age at this time—a man unfettered by the traditions that had kept our naturalists in the wake of those of France, and a warm advocate for generic divisions founded on the consideration of every character. He was the first in these Islands to adopt *Chelifer*; and the first to dismember it by the establishment of a second genus. The species listed are not necessarily British; among them, however, is *Chelifer trombidioides* Latr.—*Obisium trombidioides* Leach's MSS.—which had been found by Montagu in Devonshire, and by Leach in Surrey. = *Chthonius* sp.

10. Leach, W. E.—A tabular View of the external Characters of Four Classes of Animals which Linné arranged under Insecta. Trans. Linnean Society, xi. pp. 306–400. London, 1815.

In this memoir Leach characterizes *Chelifer* and *Obisium* as separate genera; and describes "*Chelifer fasciatus*": Habitat sub cortice arborum; but without locality.

11. Leach, W. E.—Annulosa. *In* Encyclopædia Britannica; Supplement, i. pp. 401–53. Edinburgh, 1816.

He states here that "*Chelifer fasciatus*" inhabits beneath the bark of willow and other trees and occurs sometimes near London; cf. Leach (**12**) = **Chelifer (Chernes) cimicoides** (Fabr.).

12. Leach, W. E.—On the Characters of the Genera of the Family Scorpionidea, with Descriptions of the British Species of Chelifer and Obisium. Zoological Miscellany, iii. pp. 48–53. London, 1817.

This memoir comprises—according to a statement probably by Leach himself—a valuable monograph on the British species of *Chelifer* and *Obisium*, illustrated with very accurate figures of the whole.* It is the first attempt to present in such a manner this part of our fauna; and it is noteworthy that, except in the work of Hermann already mentioned, no similar task had been

* Leach ?—*In* Samouelle's Entomologist's Useful Compendium. London, 1819.

undertaken for the false-scorpions of any region. The British fauna is believed to comprise eight species. They are not all regarded as new; but oddly they all receive new names, the older names of Hermann and Latreille and "*Chelifer fasciatus*" of Leach himself being reduced to synonyms. The classification and nomenclature are as follows:

Family *Scorpionidea.*

Genus *Chelifer.*

Sp. 1. *Chelifer Hermanni.*
Sp. 2. *Chelifer Latreillii.*
Sp. 3. *Chelifer Olfersii.*
Sp. 4. *Chelifer Geoffroyi.*
Sp. 5. *Chelifer museorum.*

Genus *Obisium.*

Sp. 1. *Obisium orthodactylum.*
Sp. 2. *Obisium muscorum.*
Sp. 3. *Obisium maritimum.*

These eight species are dealt with in synoptical fashion and figured. The diagnoses, however, are meagre; and the figures, on copper plates by R. P. Nodder, are poor. Taken together they are insufficient, except perhaps in the case of "*Chelifer museorum*," for the determination of the species. Thus it happens that most of the names have been, by one author or another, misapplied; and in some cases the species intended, having been redescribed, became widely known under other names. The specimens on which the work was based, however, are preserved in the British Museum (cf. Cambridge, **27**). They have been obligingly shown to me on several occasions—acknowledgments must be made in this connection to Mr. R. I. Pocock, Dr. W. T. Calman, and Mr. A. S. Hirst—and detailed microscopical examinations have been made of them. There are eighteen specimens, representing the eight names above mentioned. They bear numbers corresponding to entries in the old catalogue-book of Leach's collections, and one individual in each case is indicated as the type. The specimens are dry, i.e. set out on card, and while some are in poor condition, the collection as a whole is well preserved.

1. *Chelifer Hermanni.* One specimen. Britain. = *Chelifer cancroides* (Linn.).

2. *Chelifer Latreillii.* One specimen. Britain. = **Chelifer Latreillii** Leach.

3. *Chelifer Olfersii.* One specimen. Britain. Palps lost and surface-sculpture obscured, not determinable with certainty. Cambridge (**27**) regards it as identical or probably identical with the next species.

4. *Chelifer Geoffroyi.* (*Chelifer fasciatus* Leach, **10**, **11**). Two specimens. Britain. Both badly corroded; but a trace of the sculpture is visible. = *Chelifer* (*Chernes*) *cimicoides* (Fabr.).

5. *Chelifer museorum.* Three specimens. Britain. = *Cheiridium museorum* (Leach).

6. *Obisium orthodactylum.* Habitat sub lapidibus, in Danmonia et Cantia vulgatissime. Four specimens. Devon and Kent. Three of them = **Chthonius Rayi** L. Koch, 1873. The remaining one, which is that indicated as the type, is uncertain from its bad condition, cf. Kew (**38**), p. 56; it is smaller than the rest and I have followed Cambridge (**27**) in regarding it as the smaller less deeply coloured species = **Chthonius orthodactylus** (Leach).

7. *Obisium muscorum.* Four specimens. Mountains of Scotland. = **Obisium muscorum** Leach. The name was misapplied by Simon (**22**); but *Obisium muscorum* Leach of most authors appears to be correctly named; cf. Kew (**38**), p. 54.

8. *Obisium maritimum.* Habitat in Anglia occidentali inter rupes ad littora maris. Two specimens. W. England. Presented by C. Prideaux, Esq. = *Obisium maritimum* Leach.

13. O.—A lobster-like Insect attacking the Leg of a House-Fly. Loudon's Magazine of Natural History, iv. p. 94. London, 1831.

This writer inquired the name of a creature having claws like a lobster by one of which it clung to the leg of a House-fly; he thus initiated a correspondence in which Professor J. S. Henslow, Mr. F. C. Lukis, and others took part; and this is the first of many similar discussions which have appeared in our magazines. The name given is "*Chelifer cancroides.*" = *Chelifer* (*Chernes*) *nodosus* Schr. ?

14. Templeton, R.—Catalogue of Irish Crustacea, Myriapoda, and Arachnöida, selected from the Papers of the late John Templeton. Loudon's Magazine of Natural History, ix. pp. 9–14. London, 1836.

Contains the first records of false-scorpions in Ireland. Two species are given in the additions to the Catalogue which bear the initials R. T. The first, without locality, is "*Chelifer musœorum* Leach" = *Cheiridium museorum* (Leach); and the second, from Island Magee, Co. Antrim, is "*Chelifer parasitica* Herm.," and is described as having "spatulate bristles"; cf. Kew **(40)** = *Chelifer* (*Chernes*) *dubius* (Camb., 1892)?

15. Westwood, J. O.—(1) Cheliferidæ. *In* British Cyclopædia of Natural History, ii. p. 10. (2) Entomologist's Text Book, pp. 145–6. London, 1836–8.

"Highly interesting . . I have captured the largest species which I have hitherto seen of the group, under the bark of trees in Windsor forest, in the act of devouring the hard-cased beetle (*Bitoma crenata*)." = *Chelifer* (*Chernes*) *cyrneus* (L. Koch, 1873)?

C. L. Koch's "Die Arachniden," x., published at Nürnberg in 1843, is the first big work on these animals. It contains descriptions of 26 species, mostly German, and there are eleven plates of them, engraved on copper and coloured, and comprising altogether 32 figures. The work is in many respects well done, both descriptions and figures affording evidence of close study; and the author gave attention to certain details which subsequent writers would have done well to notice. *Chthonius* is established here.

16. Curtis, J.—Observations on the Natural History and Economy of various Insects affecting the Potato-crops. Journ. Royal Agricultural Society, x. pp. 70–118. London, 1849.

In this paper, written from Hayes near Uxbridge, Curtis describes and beautifully illustrates, without mention of locality, a false-scorpion which had occurred in numbers among decaying potatoes: *Chelifer inœqualis* sp. nov. = **Chelifer (Chernes) nodosus** Schr.

The often-quoted memoir of A. Menge "Ueber die Scheerenspinnen, Chernetidae," appeared at Danzig (N. Schr. Natf. Ges., v.) in 1855. The text leaves something to be desired in certain respects, and the figures are crude, but the work is noteworthy from the fact that it deals with species fossil in amber as well as with recent species and with internal as well as external structure. *Cheiridium* is established here.

17. Lubbock, J.—Notes on the Generative Organs, and on the Formation of the Egg in the Annulosa. Phil. Trans. Royal Society, cli. pp. 595–627. London, 1861.

An important, much overlooked, work; with a section on "Scorpionidæ" containing much of value concerning "*Chelifer*" and "*Obisium*," the former [= *Chelifer* (*Chernes*) sp.] found "under some planks which were lying on a hot-bed in our kitchen-garden" [in Kent].

18. McIntire, S. J.—(1) On Pseudo-Scorpiones. Journ. Quekett Microscopical Club, i. pp. 8–14. (2) Pseudoscorpions. Hardwicke's Science-Gossip, v. pp. 243–247. London, 1868–9.

These papers are particularly noteworthy. The author was an enthusiastic member of this Club, deriving entertainment from the use of the microscope, and with a passion for making out the external features and habits of small creatures. He was more intimately acquainted with false-scorpions than were any of our previous authors. Seven or eight species came under this writer's notice; and some were kept in captivity for long periods, his observations on them being of much interest. He was concerned for the most part with two species, of which he presented specimens to the Club, and they are still preserved in our collections. The first, named "*Chelifer Latreillei*," was found "in considerable abundance in a brewery at Theale, Berks., by F. Blatch, Esq., inhabiting the dark corners of the ale-store." = **Chelifer (Chernes) Panzeri** C. L. Koch. The second, named "*Obisium orthodactylum*," was found by McIntire, no doubt in the London district, under stones, brick-bats, etc., and in cellars. = **Chthonius tetrachelatus** (Preys.).

19. Koch, L.—Uebersichtliche Darstellung der europäischen Chernetiden (Pseudoscorpione). Nürnberg, 1873.

L. Koch undertakes, in this small work of vi + 68 pp., without illustrations, a revision of the false-scorpions of Europe. He recognizes 48 species and 9 genera; and the work is of importance, nothing similar having been attempted by any previous writer. He had received English specimens from the Rev. O. P. Cambridge; and this fact is indicated for five species: (1) *Chernes Hahnii* (C. L. Koch) = *Chelifer* (*Chernes*) *cimicoides* (Fabr.); (2) *Chthonius Rayi* sp. nov.; (3) *Chthonius trombidioides* (Latr.)

= *Chthonius tetrachelatus* (Preys.); (4) *Roncus lubricus* gen. et sp. nov.: "Rvd. O. P. Cambridge fand diese Art in England," = **Obisium (Roncus) lubricum** (L. Koch); and (5) *Roncus Cambridgii* gen. et. sp. nov.: "Bis jetzt nur in England (Rvd. O. P. Cambridge) gefunden," = **Obisium (Ideoroncus) Cambridgii** (L. Koch).

20. Stecker, A.—Ueber die geographische Verbreitung der europäischen Chernetiden (Pseudoscorpione). Archiv für Naturgeschichte, xli. pp. 157–182. Berlin, 1875.

A worthless memoir by the notorious inventor of "*Gibocellum.*" Lists eight species as British, including "*Chelifer Schaefferi*" = *Chelifer Latreillii* Leach ?; and "*Chelifer ixoides*" = *Chelifer cancroides* (Linn.) ?

21. Dale, C. W.—History of Glanville's Wootton, p. 392. London, 1878.

Records "*Chernes Reussii* (C. L. Koch); rare, and new to Britain." = *Chelifer* (*Chernes*) *nodosus* Schr. ?

22. Simon, E.—Les Arachnides de France, vii. Paris, 1879.

This volume (pp. 1–76 and three plates) contains a general account of the false-scorpions and a particular account of the French species. Acknowledgments are made to L. Koch (**19**): "Cette excellente révision nous servira de guide, et nous aurons même peu de chose à y ajouter, ayant communiqué, il y a quelques années, toutes nos espèces au Dr. L. Koch, pour en donner les descriptions"; but the work contains much that is new, and none has become more widely known or has been more often quoted. England appears, in the extra-French distribution, under several species; e.g. *Chelifer Degeerii* C. L. Koch. = *Chelifer Latreillii* Leach.

23. Crowther, H.—Chelifer Degeerii C. L. Koch, a species new to Britain. Zoologist (3) vi. p. 465. Hardwicke's Science-Gossip, xviii. p. 277. London, 1882.

Found at North Berwick. = *Chelifer Latreillii* Leach.

At this period our animals were being studied in several countries. Simon's account of the French species (**22**) has been referred to above. Tömösváry's "Pseudoscorpiones Faunæ Hungaricæ," an important work of 122 pages and 5 plates, appeared at Budapest in 1882; Canestrini's "Chernetides Italici," another important work with many illustrations, at Padua in

1885; and about this time, also, appeared the first contributions to this subject by H. J. Hansen—master of essential detail and inimitable draftsman—whose works were published at Copenhagen in 1884–5. His "Arthrogastra Danica: en monographisk Fremstilling af de i Danmark levende Meiere og Mosskorpioner, med Bidrag til sidstnævnte Underordens Systematik" (Nat.-hist. Tids. (3), xiv. pp. 491–544), and the beautifully illustrated account of the same animals in "Zoologia Danica" (4de. Hefte, Spindeldyr), though long neglected by "the arachnologists of the great nations," far surpass in value anything previously done in this Order.

24. Cambridge, O. P.—Pseudoscorpions new to Britain. Naturalist, x. p. 103. London, 1885.

(1) From Dorsetshire and Yorkshire: *Chernes nodosus* (Schr.) = *Chelifer* (*Chernes*) *nodosus* Schr. (2) From Dorsetshire, among moss in woods in the neighbourhood of Bloxworth: **Chthonius tenuis** L. Koch. (3) From Kent, received in 1880 from Mr. W. P. Haydon, of Dover, found by that gentleman in his oil-mills: *Chelifer subruber* Sim. = **Chelifer (Withius) subruber** Sim. The last was almost certainly imported; but it appears to have established itself in Britain (cf. Kew, **38**).

25. Cambridge, O. P.—A Contribution towards the knowledge of the Arachnida of Epping Forest. Trans. Essex Field Club, iv. pp. 41–5. Buckhurst Hill, 1886.

Records *Obisium simile* L. Koch, presumably from near Theydon Bois; but the species intended is *Obisium muscorum* Leach. The explanation of this and other records of *Obisium simile* as British is that Simon (**22**) confused *Obisium simile* L. Koch and *Obisium muscorum* Leach under the former name and applied Leach's name to another species (cf. Cambridge, **27**; and Kew, **38**).

In 1887, L. Balzan commenced at Asuncion (Paraguay) his "Chernetidæ nonnullæ Sud-Americanæ"; and, in 1888, published his "Osservazioni morfologiche e biologiche sui Pseudo-Scorpioni del Bacino dei Fiumi Paranà e Paraguay." In 1888, also, appeared at Moscow (Bul. Soc. Nat., n. s., ii. pp. 416–61) Croneberg's "Beitrag zur Kenntniss des Baues der Pseudoscorpione": a work of much service in the study of this Order.

26. Cambridge, O. P.—On New and Rare British Spiders. Proc. Dorset Natural History etc. Field Club, x. pp. 107–138. Dorchester, 1889.

Records *Chelifer peculiaris* L. Koch [found by the Rev. F. O. P. Cambridge in an old building at Hyde, near Bloxworth]; but the species intended is *Chelifer* (*Withius*) *subruber* Sim.

In 1890, L. Balzan reissued and completed his "Chernetidæ nonnullæ Sud-Americanæ" (of which three parts only had appeared) in a valuable memoir with a long series of illustrations: "Revisione dei Pseudoscorpioni del Bacino dei Fiumi Paranà e Paraguay" (Genova, Ann. Museo Civ. st. nat., xxix. pp. 401–451); and in 1891–2 this work was followed by his "Voyage de M. E. Simon au Venezuela: Chernetes" (Paris, Ann. Soc. ent., lx. pp. 497–552) in which the author proposed an elaborate classification. The two main divisions, Panctenodactyli and Hemictenodactyli, first appear here.

27. Cambridge, O. P.—On the British Species of False-Scorpions. Proc. Dorset Natural History etc. Field Club, xiii. pp. 199–231. [Also separately with the title: Monograph on the British Species of Chernetidea, or False-Scorpions.] Dorchester, 1892.

This work, of 33 pages and 3 plates, contains the first attempt since Leach's time to describe and illustrate our False-Scorpions. It possesses the distinctive charm of the writings of its kindly author—then and now Rector of Bloxworth and withal one of the two or three really learned arachnologists of this time—and it has been much used and much appreciated by our naturalists. Moreover, it was a genuine contribution to knowledge, for the author calls attention to the existence in the British Museum of Leach's types, and gives the results of his examination of them, together with descriptions of two new species. The work is grounded on L. Koch (**19**) and Simon (**22**); and suffers somewhat from not taking into consideration the important studies published during the years which had elapsed since the publication of those works. Further, it is well to remember that the author's studies in these animals were along a by-path from which he would, no doubt, be eager to return to the main course of his spider-work; and the same consideration applies to Simon—to whom specimens were submitted—for though "undoubtedly at the head of all living arachnologists," he had, as he told us a little later, "depuis longues années négligé l'étude des Chernetes pour nous occuper exclusivement de celle des

vraies Araignées." * The British fauna, according to the present work, comprised 20 species. All of them are described in pleasant non-technical fashion; and all are figured, often with enlargements of detail, from drawings by the author himself. The classification and nomenclature are as follows:

Order *Chernetidea.*

Family: *Cheliferidæ.*

Group I.—*Four Eyes.*

† *Chthonius orthodactylus*, Leach.
† *Chthonius Rayi*, L. Koch.
† *Chthonius tetrachelatus*, Preyssler.
† *Chthonius tenuis*, L. Koch.
† *Obisium muscorum*, Leach.
Obisium sylvaticum, C. L. Koch.
† *Obisium maritimum*, Leach.

Group II.—*Two Eyes.*

† *Roncus Cambridgii*, L. Koch.
† *Roncus lubricus*, L. Koch.
Chelifer Hermannii, Leach.
† *Chelifer cancroides*, Linn.
Chelifer meridianus, L. Koch.
† *Chelifer subruber*, Sim.
† *Chelifer Latreillii*, Leach.

Group III.—*No Eyes.*‡

† *Chernes nodosus*, Schr.
Chernes insuetus, sp. n.
† *Chernes cimicoides*, Fabr.
Chernes dubius, sp. n.
Chernes phaleratus, Sim.
† *Chiridium museorum*, Leach.§

* Simon, E.—Note sur quelques Chernetes de Ligurie. Genova, Ann. Museo Civ. st. nat. (2), xvi. (1896), pp. 372–6.

‡ *Cheiridium* is incorrectly supposed to be eyeless.

§ Opportunity must here be taken to acknowledge anew my indebtedness to the author. In years gone by—and it is a sad reminder of the flight of time that my first specimens were despatched thirty years ago—he examined many of these animals for me; and more recently has not hesitated to lend me specimens from his collections. During 1906–10, for instance, I was permitted to see the types of

The 14 species marked † were already known as members of our fauna. With regard to the other names: (1) "*Obisium sylvaticum*," a single specimen badly mounted = *Obisium* (*Roncus*) *lubricum* (L. Koch); (2) "*Chelifer Hermannii*" = *Chelifer cancroides* (Linn.); (3) "*Chelifer meridianus*," a single specimen from Bloxworth, = *Chelifer* (*Chernes*) *cimicoides* (Fabr.) ?; (4) *Chernes insuetus*, from Mr. Haydon's oil-mills, foreign to our fauna; (5) *Chernes dubius*, found by the author at Glanville's Wootton and by the Rev. F. O. P. Cambridge at Sherborne, = **Chelifer (Chernes) dubius** (Camb.); (6) "*Chernes phaleratus*," found by Mr. W. F. Blandford under bark of trees in the New Forest in May 1890, = **Chelifer (Chernes) scorpioides** Herm.

H. J. Hansen published at Copenhagen, in 1893–4, a valuable memoir: "Organs and Characters in different Orders of Arachnids" (Kjöbenhavn, Ent. Medd., iv. pp. 137–251) containing for Pseudoscorpiones a classification which improves and simplifies that of Balzan. Many errors which had become current —and are unfortunately still current—are exposed; and the then recent papers of H. M. Bernard are criticized. That author's often-quoted "Notes on the Chernetidæ" (London, J. Linn. Soc. Zool., xxiv. 1894, pp. 410–30) is full of misconceptions; and it is hoped that the practice of repeating them in our books will be discontinued. All Bernard's Arachnida-work (done hastily in connection with the controversy about *Limulus*) requires critical consideration. Barrois' magnificent "Mémoire sur le développement des *Chelifer*" [*Garypus*], with a long series of illustrations, was published at Geneva (Rev. Suisse Zool., iii. pp. 461–98) in 1896.

28. Carpenter, G. H.—["Chernes phaleratus (Sim.)" in Ireland]. Irish Naturalist, v. p. 215. Dublin, 1896.

Taken at Woodenbridge, Co. Wicklow, by Mr. J. N. Halbert. = *Chelifer* (*Chernes*) *dubius* (Camb.) ? *

Ellingsen's "Norske Pseudoscorpioner" (Christiania Vid.-Selsk. Forh. 1896, No. 5, pp. 1–21) appeared in 1897 [Supplement, Id., 1903, No. 5, pp. 1–19]; and Tullgren's "Bidrag till kännedomen om Sveriges Pseudoscorpioner" (Ent. Tidskr. Stockholm, xx. pp. 161–82) in 1899.

Chernes insuetus and *Chernes dubius*, and the specimens recorded as "*Chelifer meridianus*" and "*Chernes phaleratus*." That recorded as "*Obisium sylvaticum*" had passed out of the author's possession; but facilities for examining it were afforded me by a mutual friend in 1909. Cf. Kew (**38**), pp. 41, 54.

* Cf. Kew, H. W.—Notes on the Irish False-Scorpions in the National Museum of Ireland. Irish Nat., xviii. (1909), pp. 249–50.

29. Godfrey, R.—Chernetidea or False Scorpions of West Lothian. Annals of Scottish Natural History, x. pp. 214–17. Edinburgh, 1901.

Records "*Chernes phaleratus* (Sim.)" from Northbank, Bo'ness. = *Chelifer* (*Chernes*) *dubius* (Camb.).

30. Donisthorpe, H.—Notes on the British Myrmecophilous fauna (excluding Coleoptera). Entomologist's Record, xiv. pp. 14, 67. London, 1902.

Records "*Chthonius Hahnii* C. L. Koch" in nest of *Lasius fuliginosus* at Oxshott. = *Chthonius Rayi* L. Koch ?

31. Evans, W.—(1) *Chelifer* (*Chernes*) *tullgreni* Strand in Scotland. (2) *Chernes dubius* Cambr. (= *C. tullgreni* Strand) in Scotland. Annals of Scottish Natural History, xii. pp. 120–1; 249–50. Edinburgh, 1903.

This animal, which Mr. Evans allowed me to see in 1903, is that from Bo'ness already recorded as "*C. phaleratus*" by Godfrey (**29**). = *Chelifer* (*Chernes*) *dubius* (Camb.).

An elaborately illustrated work on the anatomy etc. of Pseudoscorpiones [in Russian] by J. P. Schtschelkanowzeff was published in Moscow in 1903 (Gelehrte Schriften d. Moskauer Universität, Nat. Abt.) Cf. the author's "Beiträge zur Kenntnis der Segmentierung und des Körperbaues der Pseudoscorpione" (Zool. Anz., xxvi., 1903, pp. 318–34).

32. Cambridge, O. P.—On New and Rare British Arachnida. Proc. Dorset Natural History etc. Field Club, xxvi. pp. 40–74. Dorchester, 1905.

Records *Chernes cyrneus* L. Koch new to Britain [a grand addition to our fauna; found in Sherwood Forest, in 1900 or 1901, by Dr. G. W. Chaster *]. = **Chelifer (Chernes) cyrneus** (L. Koch). Also "*Chernes rufeolus* (Sim.)" from "the Holborn Granary" and "*Chernes phaleratus* (Sim.)" from Dagenham, Essex; both = *Chelifer* (*Chernes*) *Panzeri* C. L. Koch.

33. Cambridge, O. P.—*In* Dyer, W. T. T.—The Wild Fauna and Flora of the Royal Botanic Gardens, Kew. Kew Bulletin, Add. ser., v. pp. 53–65. London, 1906.

* Kew, H. W.—*Chernes cyrneus* in Nottinghamshire: a recent addition to the known False-Scorpions of Britain. Nottingham, Trans. Nat. Soc., 1905–6, pp. 41–6.

Records "*Chthonius tetradactylus*" found inside a flower in the rockery. = *Chthonius tetrachelatus* (Preys.) ?

A big work by C. J. With : "The Danish Expedition to Siam, 1899–1900. Chelonethi : An Account of the Indian False-Scorpions together with studies on the Anatomy and Classification of the Order" (Kjöbenhavn, Vid. Selsk. Skr. 7, iii. pp. 1–214) was published in 1906 ; and about this time also several other works by the same author appeared either in Copenhagen or London : all of the first order of importance. With's grasp of the subject is remarkable ; and, among all his brilliant work, the studies in *Chelifer* s. l. are particularly valuable. He availed himself fully of the good diagnostic characters already used by H. J. Hansen (whose pupil he was), and discovered many new characters of wide practical importance. Hansen and With are the institutors of the modern study of Pseudoscorpiones, and a knowledge of their work is essential to the equipment of those who attempt to deal with these animals.

34. Cambridge, O. P.—On New and Rare British Arachnida. Proc. Dorset Natural History etc. Field Club, xxviii. pp. 121–48. Dorchester, 1907.

Records *Chernes minutus* Ell. from Elmer's End, Beckenham. = *Chelifer* (*Chernes*) *scorpioides* Herm.

35. Ellingsen, E.—Notes on Pseudoscorpions, British and Foreign. Journ. Quekett Microscopical Club (2), x. pp. 155–72. London, 1907.

An elaborate report on a collection received from me in 1906. Records (1) *Chelifer Chyzeri* (Töm.), from Burnham Beeches (Buckinghamshire), two specimens found under the bark of a beech-stump, in 1905, = **Chelifer (Chernes) Chyzeri** (Töm.); and (2) *Chelifer Wideri* C. L. Koch, found at West Wickham (Kent), and in Sherwood Forest, under the bark of old oaks, in 1905 and 1906. = **Chelifer (Chernes) Wideri** C. L. Koch.

36. Godfrey, R.—The False-Scorpions of Scotland. Annals of Scottish Natural History, xvii. pp. 90–100, 155–61 ; xviii. pp. 22–26, 153–63 ; xix. pp. 23–33. Edinburgh, 1908–10.

The Rev. R. Godfrey, who had already contributed several smaller papers to the "Annals of Scottish Natural History," gives here the final account of his Scottish field-work.* No

* Godfrey left Scotland for South Africa during the printing of these papers, and continued there his work on this Order ; cf. Ellingsen's "Pseudoscorpions of South Africa based on the Collections of the

additions to the British fauna are made; but our knowledge of the range northwards, more especially along the west coast, of several species is greatly extended; and the pages are crowded with observations on the natural history of the animals. *Chthonius orthodactylus* (Leach), not seen by the author, is erroneously listed for Scotland.

37. **Kew, H. W.**—(1) A Holiday in South-Western Ireland: notes on some False-Scorpions and other Animals observed in the Counties of Kerry and Cork. (2) On the Irish species of Obisium [s. s.]; with special reference to one from Glengariff new to the Britannic fauna. Irish Naturalist, xix. pp. 64–73; 108–112. Dublin, 1910.

Records, from Glengariff, Co. Cork, a large *Obisium* (*O. muscorum* Sim., *nec* Leach), found in 1909, on a rocky wooded hill-side, in moulting- and brood-nests under the outer bark of Arbutus-trees [and in 1910, in the same place, under the same conditions, and in rock-crevices and among dead leaves]. = **Obisium Carpenteri** nom. nov. The animal is unknown in Britain.

38. **Kew, H. W.**—A Synopsis of the False-Scorpions of Britain and Ireland. Proc. Royal Irish Academy, xxix. B., pp. 38–64. Dublin, 1911.

This memoir, of 27 pages and three plates, attempts to place our knowledge of the British and Irish species on a firm basis. The classification is derived from Balzan, Hansen, and With; but gives less weight to the presence or absence of the "galea"; etc. Brief comparative descriptions, and outline figures (intended primarily to illustrate the general shape of the palps), are given of 22 species. One of them, found in manure-heaps etc. and on flies' legs in several localities, is an addition to the fauna: **Chelifer (Chernes) Godfreyi** sp. nov.

An able and adequately illustrated account of the false-scorpions known in Switzerland: "Catalogue des Invertébrés de la Suisse: Pseudoscorpions," by Dr. R. de Lessert, was published by the Muséum d'Histoire naturelle de Genève, in 1911.

39. **Standen, R.**—The False-Scorpions of Lancashire and some

South African Museum, Cape Town" (Ann. S. Afric. Mus., x., 1912, pp. 75–128).

adjoining counties, with a preliminary list of records. Lancashire Naturalist, v. pp. 7–16. Darwen, 1913.

Records *Chelifer Wideri* C. L. Koch (so identified by me) from two localities in Lancashire; but it has since been found that two species had been confused under that name (cf. Kew, **40**); the Lancashire specimens (of which one is figured) = **Chelifer (Chernes) Powelli** Kew.

40. Kew, H. W.—A Synopsis of the False-Scorpions of Britain and Ireland: Supplement. Proc. Royal Irish Academy, xxxiii. B., pp. 71–85. Dublin, 1916.

Contains a redescription of *Chelifer* (*Chernes*) *Wideri* C. L. Koch, and descriptions and outline figures of *Chelifer* (*Chernes*) *Powelli* sp. nov., found in several localities in Britain, and a *Chthonius*, discovered in 1915 by Mr. J. N. Halbert, on the seashore, at Malahide, Co. Dublin. = **Chthonius Halberti** sp. nov. The latter species has since been found in Britain.

This part of our fauna thus consists, as far as is known at present, of the 24 species whose names appear in heavy type in the foregoing pages. The list of them as given in the last-quoted paper is repeated below.

List of the False-Scorpions of the British Islands.

PSEUDOSCORPIONES.

I. *Panctenodactyli.*

CHELIFERIDAE.

Chelifer.

1. *Chernes.*

1. Chelifer (Chernes) nodosus Schr., 1803.
2. Chelifer (Chernes) Godfreyi Kew, 1911.
3. Chelifer (Chernes) Chyzeri (Töm., 1882).
4. Chelifer (Chernes) scorpioides Herm., 1804.
5. Chelifer (Chernes) dubius (Camb., 1892).
6. Chelifer (Chernes) Powelli Kew, 1916.
7. Chelifer (Chernes) Wideri C. L. Koch, 1843.
8. Chelifer (Chernes) Panzeri C. L. Koch, 1836.
9. Chelifer (Chernes) cyrneus (L. Koch, 1873).
10. Chelifer (Chernes) cimicoides (Fabr., 1793).

2. *Chelifer.*

11. Chelifer (Chelifer) Latreillii Leach, 1817.
12. Chelifer (Chelifer) cancroides (Linn., 1758).

3. *Withius.*

13. Chelifer (Withius) subruber Sim., 1879.

Cheiridium.

1. Cheiridium museorum (Leach, 1817).

II. *Hemictenodactyli.*

OBISIIDAE

Obisium.

1. *Ideoroncus.*

1. Obisium (Ideoroncus) Cambridgii (L. Koch, 1873).

2. *Roncus.*

2. Obisium (Roncus) lubricum (L. Koch, 1873).

3. *Obisium.*

3. Obisium (Obisium) muscorum Leach, 1817.
4. Obisium (Obisium) Carpenteri Kew, 1910.
5. Obisium (Obisium) maritimum Leach, 1817.

CHTHONIIDAE.

Chthonius.

1. Chthonius Halberti Kew, 1916.
2. Chthonius Rayi L. Koch, 1873.
3. Chthonius orthodactylus (Leach, 1817).
4. Chthonius tenuis L. Koch, 1873.
5. Chthonius tetrachelatus (Preys., 1790).

ON SPORANGIAL CHARACTERS OF MYCETOZOA AND FACTORS WHICH INFLUENCE THEM.

By A. E. Hilton.

(*Read June 27th*, 1916.)

Plate 9, Figs. 1–2 in text.

It is perhaps not sufficiently realised that in the small group of the Mycetozoa we have not only a convenient microcosm of elementary biological phenomena, but also a clue to the solution of some of the problems which those phenomena present. Applying to the Mycetozoa words used by an eminent physiologist in a similar connection, it may be said of these primitive organisms that they show with singular clearness how "quite simple combinations of well-known forces lead to the performance of complicated and apparently purposeful results." * In the light of this luminous principle, which is true of all living things, we will consider some of the sporangial characters of Mycetozoa.

It is, of course, important that the principle so expressed should not be misunderstood. It is not stated that complicated and apparently purposeful results are brought about by simple forces; but by well-known forces in simple combination. The distinction is vital. It is the combinations which are simple, not the forces. The forces, though well known, are mostly inscrutable.

In appearance, the sporangia of Mycetozoa present a strange

* *Principles of General Physiology.* By Professor Bayliss of University College, London. 1916. The passage is given as quoted in the *Times* Literary Supplement.

variety, especially after the liberation of the spores. For example, the enclosing wall of *Diderma floriforme* splits into strips which curl backward and simulate the petals of a flower. In the lovely genus Arcyria, the capillitia are expanding nets of wonderful delicacy and beauty. *Alwisia bombarda*, found in Ceylon and Jamaica, is a remarkable species with a capillitium of stiff fibres, quaintly resembling a shaving-brush. Nevertheless, despite all diversities of ultimate shapes, the initial forms from which they spring are not difficult to account for. Owing to the surface tension of the plasm of which it consists, a sporangium, in the first instance, is necessarily of a rounded contour. Indeed, some sporangia are almost perfect spheres; the surface tension, in such cases, finding almost complete expression, as in the familiar instance of a mercury globule, or a soap-bubble floating in air. At the surfaces of liquids or semi-fluids, the tension tends to produce spherical forms because it behaves like a stretched elastic membrane seeking to contract; and a sphere has the smallest surface for the volume it contains.

It will help us to comprehend the aberrations from the spherical form which occur in the majority of the Mycetozoa if we bear in mind other facts concerning this well-known force, which plays so important a part in biology. Surface tension, as now understood, is a manifestation of cohesive force; that is, of the mutual attraction between molecules. Interiorly, this attraction is equal in all directions, and therefore balanced; but molecules at surfaces are subject to the unbalanced pull of interior molecules, and this produces the tension which results in sphericity. The force varies with circumstances. The denser the body the greater the strain at the surface; the more fluid it is, the less the strain. Changing temperatures, causing expansions or contractions, produce similar effects. Cold increases surface tension; heat lessens it; so also do electrical charges. It is therefore easy to understand that changing conditions of warmth and humidity, or electricity in the atmo-

sphere, may modify the spherical tendency of the highly plastic plasm of rising sporangia.

Other modifying influences are the ingredients of the plasmodia producing the sporangia. These may be roughly classified as colloids, colloidal solutions, and suspensoids. The purer colloids constitute the essential plasm, the living substance which divides into spores after being relieved of its impedimenta. The colloids in solution are albuminous refuse resulting from metabolism. In the developing sporangia, they gelatinise into pellicles, or coagulate into cartilaginous membranes either at interfaces or exteriors, where they are trapped by the surface tension and so concentrated. The suspensoids are particles of mineral or vegetable substances, gathered up by the plasmodia in their amoeboid wanderings and held in more or less stable suspension until deposited owing to concentration, or to being trapped, like the refuse colloids, at surfaces or interfaces. These particles are mainly of a calcareous or cellulose nature, and furnish materials of which the supporting structures, viz. stalks, columellae and capillitia, are chiefly composed.

To the interaction of these varying factors we must add capillary effects due to watery condition of the plasm, also effects of gravitation and of any lateral pressure there may be by reason of congested surroundings. Desiccation likewise gives rise to many and often strange distortions, owing to unequal distribution of impedimenta in the plasm, and consequent unequal shrinkage in drying. Putting all these considerations together, we see that sporangial forms are functions of many variables, and that the diversified results exhibited after desiccation and rupture of sporangia walls are scarcely to be wondered at. We already perceive that "quite simple combinations of well-known forces lead to the performance of complicated and apparently purposeful results." The results are indeed manifold, but the purposes we read into them are usually imaginary.

To establish the proposition that sporangia of Mycetozoa when not actually spherical are to be regarded as globular forms

modified and often distorted by factors which resist the surface tension of the plasm, we will analyse the genera of the group, in order to weigh the influence of these factors and trace their distribution. This we can do by adopting the following conventional figures as representing typical forms, with intermediate connections, and grouping around these conventional figures the natural forms approximating thereto.

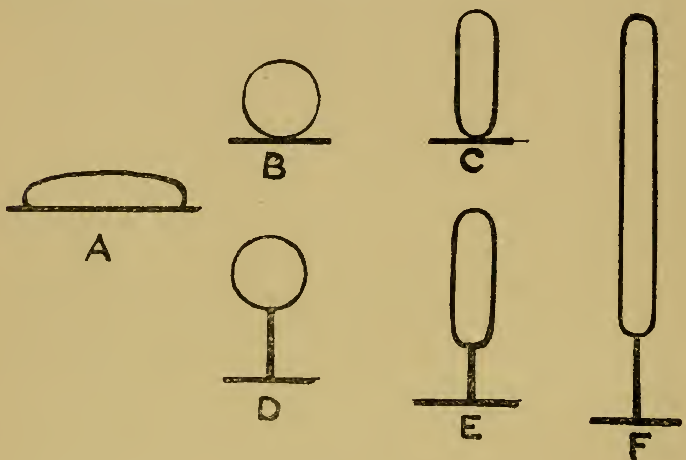


Fig. 1.

It will be seen that A and C are depressed and elevated variations of B; that D and E are stalked varieties of B and C; and that F is E much elongated.

A. *Depressed Forms.*—These mainly illustrate the effects of gravitation and low surface tension. Depressed symmetrical forms are either simple sporangia or cushion-like structures consisting of confluent sporangia combined into what is called an aethalium. Other and unsymmetrical forms spread on the substratum with an irregular outline. They are known as plasmodiocarps and are often much distorted. The majority of the sixteen genera of the Calcarineae present these flattened or irregular forms, owing to the quantity of lime (calcium carbonate) which their plasm contains. Of the thirty-two other

genera of the Mycetozoa, which are without lime, less than half show such forms. These are due to the fluidity of their plasm, or to the aethalial confluences resulting therefrom. The weaker the surface tension the less support it affords to the mass, and the greater the depression by gravitation. Capillary effects and distortion by shrinkage in drying are likewise pronounced.

B. *Globular Forms.*—In these the spherical tendency of the surface tension finds its clearest expression. If for a moment we use the language of art rather than of science, we may say that "the complete and consummate form" which is hinted at by the Mycetozoa is a perfect sphere. These globular shapes are exhibited by less than half the genera of the Calcarineae, the lime often being an impediment. Of the remaining genera about half exhibit them.

C. *Cylindrical or Vertical Forms.*—In this diagram the sphere is distorted by being drawn upwards, the vertical axis gaining length at the expense of the horizontal circumference. The natural forms which group themselves round this conventional figure are significantly few and diverse. Only two genera of the Calcarineae, and six of the remaining genera, exhibit them; altogether but one-sixth of the forty-eight genera of Mycetozoa. In most cases the more or less cylindrical sporangia are somewhat curved; in other instances they are clavate (club-shaped) or pyriform (pear-shaped), much larger at the apex than at the base. These latter suggest a tendency to form a stalk. In the main these upstanding forms result from lateral compression, the sporangia being so crowded on the substratum that in order to relieve the side pressure the plasm is forced to extend upward, that being the only direction in which relief is possible. In those genera in which the sporangia stand singly, the upward extension is due to the surface strains being modified by unequal distribution of interior deposits, or varying concentrations of the plasm. The definite relation between interior densities and surface tensions obviously affects the shape of a sporangium when from any cause such densities vary throughout the mass.

D. *Globular Forms with Stalks.*—Here again, as in the sessile forms B, the plasm follows to a great extent its natural tendency to round off into spheres; but not until it has deposited a stalk on which it raises itself from the substratum by clinging to the upper end and drawing up from the base. More than half of the genera of the Calcarineae produce these forms, the lime left behind in the stalks leaving the plasm at the summit more free to assume a globular shape. Of the genera without lime about half exhibit them, the stalks of these being chiefly of a cellulose nature.

E. *Cylindrical or Vertical Forms, Stalked.*—As in the case of the sessile forms C, the genera presenting these are comparatively few, comprising four genera of the Calcarineae and five of the other genera. In one or two instances the sporangia are clustered and therefore partially moulded by lateral compression, but more frequently the vertical lengthening is a result of the stalk continuing upwards as a columella with branching capillitia nearly or quite to the summit of the sporangium. In other instances where there is no columella the sporangium is moulded on a frame of closely packed capillitia which afterwards expands into a light mass of fibrous network.

The feature which these stalked and lengthened forms pre-eminently illustrate is the effect of inner structure upon outward form. In rising sporangia the arrangement of the material which forms the capillitium is primarily controlled by the plasm which deposits it; but as the process proceeds the secreted substances harden into a scaffolding of increasing firmness, and control partially passes over from the plasm to the rigid structures, which largely determine the final shape of the sporangium. Surface tension so far operates as to draw the plasm upwards clear of the stalk, but the capillitium then arrests the climbing movement, and the compromise between these two factors, coupled with shrinkage effects of desiccation, lead to the characteristic more or less cylindrical shapes.

F. *Cylindrical Forms, Stalked and Elongated.*—This diagram

is similar to E but much elongated, and conventionally represents a few striking cases in which cylindrical forms are lengthened to an extreme degree. The genera which produce them are chiefly Stemonitis and Comatricha, which may almost be regarded as a single genus, the distinction between them being rather artificial, though convenient for classification. In Stemonitis the sporangia are sometimes four-fifths of an inch in length and fairly upright, but in Comatricha (*C. longa*, found in Asia, Africa and America) the sporangia are sometimes two inches long, and are flexuose and drooping, owing to the weakness of the columella. In both instances the fasciculate sporangia mutually support each other during formation, but after drying they are apt to separate and bend over. The only example in the Calcarineae of a form at all similar is Erionema, a genus of a single species. When sessile, the sporangia, which are very small, frequently appear as branched plasmodiocarps; but it also presents stalked and lengthened forms, prone or pendant, owing to weight of lime in the sporangium walls, and the weakness of the capillitium which is merely an expanding network of slender threads, unsupported by a columella. In all three cases the form-giving effect of interior deposits is accentuated in the exceptional length of the sporangia; but although sphericity is lost, surface tension is still evident in their cylindrical roundness. Moreover, we must remember that whatever restraints interior deposits may impose on the plasm while a sporangium is forming, surface tension at last finds full and free expression in the sphericity of the spores produced. In multitudinous spore-cases of globular shape the whole of the clarified plasm rests awhile till surroundings favour the renewal of its activities.

From this analysis we find that in the production of sporangial forms, surface tension, free or restrained, is the dominant factor; that gravitation is strongly influential; that lateral compression helps to mould some of the vertical forms; that capillary effects are traceable; and that desiccation affects more or less, and sometimes much distorts, the maturing sporangia. It is un-

doubtedly true that simple combinations of these "well-known forces" lead to "complicated and apparently purposeful results," but the supposed "purpose" always ends in simple spore-production, however intricate the processes may seem to be.

In the case of sporangia which are not sessile, the formation of a stalk becomes more intelligible when we realise the essential fact that stalk and sporangium develop concurrently as the dual result of one and the same process. A good illustration of this is furnished by the well-known species *Comatricha nigra*, the successive phases of which are indicated by the following figures:

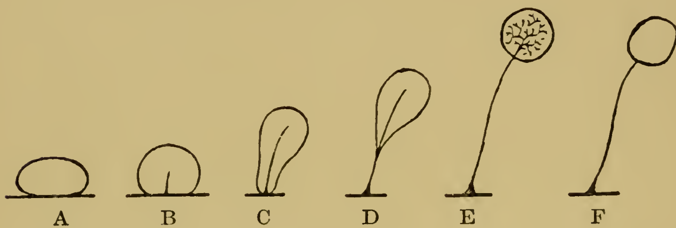


FIG. 2.

A. Cushion of watery plasm on surface of dead wood, from interior of which it has just emerged.

B. Plasm more erect, with base of stalk visible at centre.

C. Stalk lengthening upward. Plasm still adhering to base.

D. Further extension of stalk. Plasm detached from base, and being drawn upward by rounding action of surface tension.

E. Stalk at full length. Plasm rounded by surface tension. Interior secretions from plasm forming capillitium branching from summit of stalk. Capillitium partly visible. Sporangium becoming opaque.

F. Final shape of sporangium. Spherical form modified by capillitium and effects of desiccation.

This is a fair example of the general process of stalk-formation throughout the group, due allowance being made for specific differences in the plasm, especially of those species containing

lime. Both sessile and stalked sporangia are frequently produced by one plasmodium, and in such cases the presence or absence of a stalk evidently depends upon contingent rather than specific conditions.

The morphological effect of the presence of lime in sporangia is well indicated by the large proportion of species to genera in the Calcarineae as compared with other genera and species. The figures are :

	Genera	per cent.	Species	per cent.
Calcarineae	16	0·33	129	0·52
Other Endosporeae . . .	32	0·67	116	0·48
	48	1·00	245	1·00

These figures show that more than half of the species belong to the Calcarineae, although the genera containing them are but one-third of the genera included in the group. Under the varied conditions of environment in different parts of the world, lime in sporangia tends to multiply the number of characters regarded as specific. This is strikingly illustrated by the genus Physarum, which is divided into fifty-seven species, whereas the average number of species in a genus of Mycetozoa is five. From the fact that only a portion of the group contains lime, and that sporangia without lime are occasionally found even in the Calcarineae, we may conclude that calcium carbonate, although utilised by the plasm in which it occurs, is not an indispensable element of it. When afterwards eliminated it is deposited in a variety of ways, sometimes as a central ball within the sporangium, frequently in the form of a columella, generally in the stalks or embedded in the sporangium walls, or forming an outer crust of stellate crystals. There are two singular cases which also present a contrast. In Physarella there are calcareous spines attached to the sporangium walls and pointing inwards until the walls are ruptured. In Physarina the walls are covered with calcareous protuberances pointing outwards, resembling the spines of an echinus. It is appropriately named *P. echinocephala.*

In all sporangia of Mycetozoa, probably without exception,

there is material of a cellulose nature; and this must be regarded as an inevitable result of the metabolism of the plasm. It is secreted in more perfect forms than the lime, and their characteristics suggest that chemical as well as physical processes are involved in their production. The minute spore-cases, of different patterns, the slender threads of capillitia, often with excessively fine markings upon them, and sundry delicate membranes, are all of this material; and in combination with albuminous refuse, also the result of metabolism, it enters into the composition of cartilaginous stalks and sporangium walls. Speaking generally, the lime deposits are coarser and conditional; the cellulose deposits inevitable and more specific. The cellulose substance is in closer relation to the plasm; but in the processes of spore formation it is equally eliminated.

The visible changes of colour, significant of interior rearrangements, which occur while sporangia are forming are remarkable. In the case of the familiar *Comatricha nigra*, for example, the plasm, at the outset, is watery or milky white; but as formation proceeds, the colour of the sporangium successively changes to pink, light red, coral red, black and purple-brown. A specimen of *Dictydiaethalium plumbeum*, watched by me during development, appeared on a piece of branch first as a chalk-white layer, then contracted into a cushion of brilliant rose-pink, and finally matured into an aethalium of a drab-clay colour. Plasmodia of Lamproderma are watery-white or colourless, but developing sporangia, after turning brown or reddish-brown and then black, finally become iridescent, bronze-like, or shining like burnished brass. We find, indeed, that if we take into account the whole range of sporangial forms of Mycetozoa, all the prismatic colours are represented more or less closely, but in unequal degree. It is noticeable that green, blue and violet, though not absent, are in very small proportion. This suggests a tendency to absorb the light rays of the upper half of the spectrum. Conversely, the colours of the lower half of the spectrum, yellow, orange and red, are more in evidence; yellow tints preponderating, with

shades of red in fair proportion. The yellows are probably attributable to the albuminous contents of the plasm; the reds are more likely due to the cellulose substances. Both albumin and cellulose are carbon compounds with hexonic bases; and this "ring-structure," as it is called in chemical symbolism, is regarded as particularly favourable to colour development.

Purely chemical features, however, are usually obscured by changing physical conditions. In the early stages of sporangial formation, the plasm is still watery and reflective; and this, in conjunction with the presence of lime, albumin and cellulose, or any combination of them, gives rise to light and bright tints of many shades of white, yellow or red. As condensation proceeds, and interior structures are increasingly deposited, there is less reflection of white light, the colour effects of the secretions within the semi-transparent plasm become more pronounced, and the tones tend to deepen or darken. By the time the sporangium walls have formed, but while they are still moist, there is in numerous cases an almost complete absorption of light, producing a nearly black appearance. On drying off, colour reappears in most instances, but with a difference. Their prevailing hues are now shades of black, purple or brown; the browns, in beautiful variety, being in the ascendant.

In the Calcarineae the general course of the coloration processes is affected by the lime embedded in the walls, or masked by lime-crystals encrusting the sporangia. When these fall away, darker surfaces are seen. The iridescent or metallic appearances presented by certain species, both of Calcarineae and other genera, are due to prismatic or interference effects, produced by mineral particles or surface membranes, hyaline or translucent.

Here, for the present, our analysis ends. When we are asked what is the use of studying Mycetozoa, our answer is that, so far as we are able, it is our business, as microscopists and nature-students, "to make each small thing unfold its secret, and in so doing, perhaps, to unfold other and wider secrets."

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Description of Plate 9.

A.	**Fuligo septica*, ½ nat. size.	†*Dictydiaethalium plumbeum*, nat. size
B.	**Badhamia foliicola*, × 6.	†*Margarita metallica*, × 20.
C.	**Diachaea cylindrica*, × 8.	†*Hemitrichia vesparium*, × 8.
D.	**Diachaea splendens*, × 14.	†*Lamproderma arcyrionema*, × 12.
E.	**Diachaea leucopoda*, × 15.	†*Lamproderma columbinum*, × 5.

F. †*Stemonitis fusca*, nat. size.

* Containing lime. † Without lime.

A

B

C

D

E

F

A. E. Hilton del. *Adlard & West Newman.*

TYPICAL SPORANGIA OF MYCETOZOA.

ON THE BDELLOID ROTIFERA OF SOUTH AFRICA.

PART II.

By W. Milne, M.A., B.Sc., F.R.S.E.

(*Read October 24th,* 1916.)

Plates 10–14.

In a footnote * to Part I of this paper I stated that I had inadvertently made use of a generic name (Monoceros) in the description of a new Bdelloid genus, which was already preoccupied and therefore inadmissible.

I propose here to change the generic name Monoceros, with its derivatives Monocerotidae and *Monoceros falcatus*, into Henoceros, Henocerotidae and *Henoceros falcatus*.

In Part I, pp. 77–82, I gave descriptions of three new species of the genus Macrotrachela, and shall now complete my list :

Genus MACROTRACHELA.

Macrotrachela verecunda sp. nov.

Pl. 10, figs. 1–1c.

Specific Characters.—Of small size. Trunk dark brown and deeply ridged. Rostrum long and very narrow, with double lamella. Antenna long and stout, equal to fully three-fourths of neck width, and bearing long setae. Teeth two. Foot short with narrow ankle and three stumpy toes. Spurs not very long, of a distinctive shape. Corona equal to collar in width. Sulcus very narrow. A slow creeper. Size, 1/120th inch.

This is a very small animal with a dark brown trunk and very hyaline neck and foot. The trunk has uneven coarse ridges, giving it an appearance resembling the surface of the rough bark of a tree. The skin must be viscous, as fragments of the debris

* *Journn. Q.M.C.*, ser. 2, vol. xiii. p. 49.

were seen adhering to the trunk. It is rather a sluggish creeper, with a very deliberate slow pull-up of the foot. It seems to avoid the open, and to prefer to withdraw under shelter; and on account of this habit, and its small size, it is very difficult to examine.

The rostrum is very narrow, but the double lamella is quite prominent. The antenna is long and stout, and has very characteristic brushes of setae. These brushes are extremely long, and always show the same graceful curve, and so clear are they that they are easily distinguished with a 1 inch objective. There are prominences on each side of the antenna, like those seen on the spined varieties of Macrotrachela. The dental bulb is heart-shaped and there are two teeth.

The foot is short and the ankle very narrow. The spurs are rather short, and have their outer borders convex and the inner curves concave, producing a converging effect.

The shape and character of the antenna brushes and the spurs are very constant and distinctive.

The corona is equal in width to the prominent collar, and the sulcus is extremely narrow on the ventral side, the wheels almost approaching each other. The upper lip is glaucous, and refraction from parts below causes optical difficulties. What appears to be the upper lip consists of a triangle over an oblong. It is not easy to make sure whether the oblong belongs to the upper lip or is part of the rest of the corona. The apparent upper lip shows fully higher than the corona, broad across. When the lip is looked straight down upon—that is, when the animal is feeding in a perpendicular position—the upper edge is convex dorsally and shows three parts (Pl. 10, fig. 1c). The middle part seems to be the cross section of the triangular part lying on the oblong. The triangular part was not always well seen. The oblong may possibly be a high ridge from wheel to wheel crossing the sulcus, and shown up by the triangular part. The base of the upper lip is thick and raised like a frill.

Habitat.—Not very often seen, but possibly common enough, as I saw samples from three different places. They are easily overlooked on account of their small size and their habit of resting under the rubbish.

Found in ground or rock moss Grahamstown, also Euphorbia Kloof and Draaifontein farm, Uitenhage district.

Macrotrachela smithi sp. nov.

Pl. 10, figs. 2–2a.

Specific Characters.—Of large size and elongated. Corona wider than the collar, and sulcus equal to four-fifths of the disc. Upper lip a bold semicircular curve with a narrow abrupt notch in front. Antenna short, barely equal to one-third of neck width. Teeth two, well apart. Heavy rump and short foot. Spurs divergent with fairly wide convex interspace, distinctive. Toes three, stout. Size, 1/65th inch.

This is a large handsome animal. When fully extended, the width from the rostrum to the rump very gradually and scarcely perceptibly increases. The pre-anal segment is heavy, and is distinctly marked off from the trunk. Older specimens seem to creep rather laboriously, but the younger ones are active. In some there were large oil globules in the stomach investment extraordinarily like pellets, but it was noticed that only granular matter was voided. The trunk is freely ridged.

The rostrum is stout, and has a large prominent double lamella, with several long setae, some of which are motile. When feeding, the rostrum often lies over the upper lip, and whether so or tossed farther back its cilia were always seen to be in rapid motion. The short antenna has three little knobs at the end, and has on each side of it a swelling or protuberance. Small, roundish jaws bear two teeth, far apart. The contractile vesicle is large and of slow period. There are probably four segments in the foot, which is short, and ends in three stout toes. The second segment is extremely short, and may possibly be the spur segment. Spurs are of moderate length, about equal to three-fourths of the ankle width. They are widely divergent, broad at the base and narrowing suddenly on the inside half-way down, becoming very attenuated and ending in very sharp points. There is a convex interspace. An elegant appearance is given to the spurs by the graceful lines bounding them.

There is a seta with a bulbous base on each wheel of the handsome corona. The sulcus is wide and the collar prominent. Corona, collar and neck are to each other as 14, 10 and 9. The upper lip is semicircular with an abrupt notch in front, which just breaks the bold outline.

The egg is more oblong than oval, narrowing very little at the two ends.

This Macrotrachela has a general resemblance to a species of Philodina which I have seen in South Africa. The latter is similar to, if not the same as, one which Mr. Bryce has named *P. patricia*, but has not yet published a description of; he kindly sent me some specimens. The curve of the upper lip is not so bold, and the spurs though similar are not the same in detail.

Habitat.—Ground moss, Kamaehs farm, Uitenhage. The species was obtained from the one place only, but was seen on different occasions. It has not been observed again recently.

Macrotrachela timida sp. nov.

Pl. 10, figs. 3–3a.

Specific Characters.—Of large size, hyaline except the stomach investment, which is of a pale decided pink. In general appearance, more especially in the rump and spurs, it is similar to *M. plicata* (Bryce). Deeply plicate. Rostrum long and stout. Antenna equal to one-third neck width. Teeth two. Spurs divergent and decurved slightly, and equal to ankle width. Corona wider than prominent collar, with a seta on each wheel. Sulcus equal to two-thirds disc. Upper lip rises, almost square across in front. A fleshy tooth in sulcus. Size, up to 1/60th inch.

This is an exceptionally handsome animal when feeding. It has, like all having the type of rump of *M. plicata*, a most irritating, jerky manner of creeping. But this one seems wanting in pluck, and is easily stopped in travelling, by obstacles, and contracts even when meeting with slight obstruction. It does not feed readily in the open, and after a time all will have retired into hiding. Some could be discerned feeding amongst the debris, but of course details could not be made out. At last I thought of washing the rubbish off them. Waiting a day or so till they had quieted down and felt at home, I ran a drop of water under the cover-glass; this broke up the rubbish and carried it down towards the other end, and generally left *M. timida* uncovered, and feeding away gaily. They generally kept on feeding for some time very quietly and steadily, before seeking shelter again. In a few hours all would be once more hidden from view.

The rostrum is long and stout, and seems to have the quadruple lamella, but of this I could not make quite sure. There is a large brain mass. The dental bulb is winged and has two strong teeth.

The trunk is almost equal to the rest of the animal in length and shows five clear divisions of about equal length. It has the toughness and elasticity of skin of *M. musculosa*, which enables it to keep a perfectly regular shape, whether extended or contracted.

The lumbar region has what might be called the "crinoline" type. The anal segment stands out with a sort of thin almost rigid flange at bottom—one could almost imagine a wire support inside—so that whatever tightening or alteration takes place in front, the posterior maintains its wide and peculiar shape. The pre-anal segment also keeps its shape as if it were stiffened. Whether the animal is stretched or relaxed, the shape of the rump is practically constant. The lumbar region, seen sideways, looks the deepest part of the body, largely due to the lumbar plicae standing up so high. These lumbar plicae, which look like two firm smooth membranes with their lower edges deep down, rise up above the surrounding surface ; the upper edges have a convex curve longitudinally. There is an abrupt dip from the anal segment to the foot. The intestine is a large oval, but the contractile vesicle is rather small.

The foot has four segments, and has no boss. Of the segments, the first is the longest and ends in a rigid rim, the second has also a rim but smaller. The spurs are divergent and decurved, and as long as the width of the ankle. There is a very short interspace, and a slight shoulder is usually apparent just below. The spurs are often clipped together.

The corona is bold, and is to the collar as 14 to almost 11. The upper lip is clear cut and of a glassy colour. It rather more than covers the sulcus, and has a clean-cut almost straight front margin. About half-way back there is a line or ridge across the lip, and between this and the front margin on the lateral borders are two curves, probably defining skin folds. There is a short fleshy tooth on the sulcus bridge which shows in certain positions only, when the head is well up.

The egg is a broad oval, almost round, and has blunted narrow prominences all over the surface, almost touching each other.

M. timida can be kept in a slide for a considerable time.

Habitat.—Ground moss, Springfield and Euphorbia Kloof, Uitenhage, also Somerset East. They were abundant in one sample of moss, but only a few were noticed in the other samples where they occurred.

Macrotrachela timida var. *inquies.*

Pl. 10, fig. 4.

Specific Characters.—Long and rather narrow, swelling slightly towards the middle of the trunk. Rump has the crinoline arrangement permanent in all positions. Foot is fairly long and very narrow, of at least four segments and with a boss on the first. Spurs fully longer than ankle, divergent, with short interspace and a slight shoulder below. Rostrum long and narrow. Antenna short, about one-fourth neck width. Teeth two, not very large. Corona scarcely wider than the non-prominent collar, and with a seta in each wheel. Upper lip rises high, practically square in front. Size, 1/75th inch.

This is a very fast, restless, jerky creeper. The corona collar and neck are nearly equal in width. The upper lip is thick and fleshy, and rises as high as the highest part of the wheels. It springs laterally from well above the widest part of the collar, and lies almost against the secondary wreath. The front margin is fairly broad and is practically straight across when the animal is feeding in a horizontal position. Along the middle of the upper lip longitudinally, the flesh is thicker and bulges up. When the head is well below the horizontal, this elevation hides the straight front margin, and gives the appearance of a rounded margin. The pedicels are deep, and the rostrum lies far back when the corona is unfurled.

The trunk is closely ridged.

Habitat.—Ground moss, Kamaehs farm, and tree moss, Bulk River, Uitenhage.

Fairly common.

There are one or two other varieties, which differ chiefly in the nature of the foot.

These wickedly restless creepers form quite a little group—*M. plicata*, *M. plicatula*, *M. ehrenbergii*, *M. timida* and its varieties. It is quite easy to go astray among them, as one gets as a rule very little opportunity of examining all the details at a time,

they being usually shy feeders, and one may chance on another species next time when examining the field, as all are somewhat alike while creeping. Besides their similarity in habits, all have similar spurs, and the crinoline type of rump, either permanently or to a certain degree when relaxed and sitting back on the foot. *M. plicata* is the only one which has not got the unbroken front margin of the upper lip, and which is not very shy in feeding. The animal I take to be *M. ehrenbergii* has more segments than eleven, but otherwise answers fairly well to the description (1). The peculiar extensions of the rostral sheath or auricles described by Janson are evidently part of the lamella, which appears quadruple. The two inner folds were evidently taken by Janson to be the whole lamella. *M. plicatula* as I found it had the projecting broad annulus on the posterior of the first segment of the foot, and not on the second as given by Murray (6).

Macrotrachela faveolata.

Pl. 10, figs. 5–5d.

Specific Characters.—Of large size. Stomach investment deep yellow. Antenna stout. Dental bulb roundish with thick comb-like edges, bearing eight large teeth. Stout lumbar region and foot. Spurs and upper lip somewhat like those of *M. russeola*. Corona just wider than the collar. Sulcus slightly over half the width of disc. The main ridges of the trunk bear large warts or knobs, and there are small warts and dots all over the surface. Size, about 1/60th inch.

I found this fine large species several years ago, but have never met with it since. Mr. Murray also found it in some moss I sent him from the same gathering in which I discovered it. Unfortunately I have lost my notes on it, but from the sketches I still have, and the sketches Murray sent me, and a few marginal notes thereon, I am able to give sufficient data for purposes of identification.

It is in some particulars like *M. russeola*—in spurs, upper lip and general build—but it has a most extraordinary peculiarity, the possession of three kinds of processes; very large warts or knobs along the trunk ridges, from five to seven in each; and smaller sub-hemispherical warts and fine dots in extraordinary numbers all over the surface. The large warts consist of a bundle

of threads or possibly tubes, and are well seen from the side view (fig. 5c). From the front view each has an alveolar appearance (fig. 5d).

There is a curious growth in the neck.

Murray suggested the name *Callidina faveolata*, so I have retained it. I have no record of the nature of the toes, but I think it quite possible that it may have to be transferred to the genus Mniobia.

Habitat.—Rock moss, Euphorbia Kloof, Uitenhage district.

A fair number were seen in one gathering of moss. I have very often examined moss from the same place, but never had the good fortune to find the animal again.

Genus HABROTROCHA BRYCE.

Habrotrocha placida sp. nov.

Pl. 11, figs. 6–6c.

Specific Characters.—Of moderate length, very narrow and hyaline in colour. Narrow rostrum with double lamella. Inclosed wheels characteristic. Antenna very short—about one-third neck width. Teeth about eight, very small. Spurs, short cones without interspace. Corona is equal to two-thirds of the width of collar, and the pedicels are extremely short. Upper lip is bluntly triangular with large elbow-bends directed backward. Trunk is lightly stippled. Size, 1/90th inch.

This species is of a quiet, gentle habit. When placed on the slide, it may not begin feeding for a very long time, but when it does it will remain in the same position for hours, without any swaying movements, but keeping the corona perfectly steady, or shifting the head almost imperceptibly; when it does creep it does so gently and not with jerky motions.

The distinctive features are the corona and the upper lip. The corona is to the collar as 4 : 6. Its wheels have scarcely noticeable pedicels, and the primary wreath being thus so near the secondary, the interference due to their vibrations makes it difficult to observe the upper lip. The upper lip is triangular and is raised at a slight angle to the wheels. A short distance from the front each border makes an elbow-bend backwards, and uncovers its base, which is seen as a straight line. The bends can be seen high above the collar when viewed laterally. Sometimes when the

animal is apparently anxious to feed, it may be seen hesitating and evidently dubious about the advisability of unfolding the corona. On these occasions the upper lip is pushed stealthily forward, with its elbow bends compressed backwards into sharp angles, and the ends of the collar apparently thrown forward (fig. 6c). The corona is not yet unfurled, but the rostrum is thrown back.

When creeping it appears long and narrow, and makes a short gentle glide.

The inclosed wheels are a glaucous mass with a clear-cut outline, small and round with a flattened front. The lateral plicae are well marked; and the cross dorsal marking, from which the lumbar plicae spring, is unusually far forward.

When feeding, the front trunk segment usually stands well out from the neck (fig. 6). It feeds in the open. The jaws are large, but the teeth are very small and difficult to see clearly, and are possibly more than eight in number. The lumbar region is not unlike that of *Otostephanos torquatus-amoenus*, and indeed it is difficult to distinguish between the two species when creeping. I usually look first for the long setae at right angles to the rostrum which characterise *O. torquatus-amoenus.*

Habitat.—Ground and rock moss, Kamaehs, Euphorbia Kloof and Springfield. It was fairly abundant.

Another rather smaller form and probably a variety of the above was seen. The corona was very slightly wider, and in the upper lip the front part of the elbow-bend—if bend there were—could never be certainly made out. Otherwise it had the same appearance. It was deeply stippled. The number of teeth was probably seven.

Habrotrocha plana sp. nov.

Pl. 11, fig. 7.

Specific Characters.—Short and broad with narrow extremities of a bluish-grey colour. Lamella double with several long setae under it. Antenna from one-third to one-half neck width. Jaws large, teeth two, very small. Trunk very broad and slab-like; lumbar region of distinctive shape. Foot has possibly four segments, a very narrow ankle and stout toes. Spurs short. Contractile vesicle is large. Corona less than collar. Upper lip triangular. Size, 1/100th to 1/120th inch.

This is a tremendously swift creeper, and slithers or glides fully its own length before planting its toes. It is very steady when feeding, and generally feeds in a fully extended position. Every now and again, it suddenly glides along for a step or two and recommences feeding, and may keep on repeating this performance for a long time. The suddenness with which, on these occasions, it unfolds its corona and is quietly feeding again is almost startling. The pellets are often large and numerous, but sometimes scarcely distinguishable in a glairy mass.

The trunk is very broad, and flattened dorso-ventrally; and seen sideways has a slab-like appearance. The rump is peculiar, the fleshy parts are wrinkled inwards in two waves, leaving the remainder empty and glassy looking.

The corona is to the collar as 9 : 10. It has a seta on a small pimple on each wheel. When looking down on the sulcus a cord-like rim can be seen on each side, running over the edge and on to the wheel, just showing and no more, an apparent clear space between it and the wheel.

The upper lip is triangular, its two sides just visibly curved, and does not rise far up the sulcus. It is clear and glassy, and rises gradually from the two borders and the apex, towards the middle of the front of the rostral segment, somewhat like part of a dome. The rostral segment during feeding is very rounded dorsally, it bulges up from the sides, up to and round the rostrum, which occupies the greater part and stands well up, the whole having a sort of inverted-saucer appearance.

The foot has very heavy glands which pass through the anal segment. The spurs sometimes resemble a fish tail, but are usually short cones, scarcely divergent, and without interspace.

H. pulchra (2) is the nearest to this, but differs in the upper lip and the number of teeth.

Habitat.—Ground and rock moss; common in Uitenhage district; also found in Grahamstown.

Habrotrocha iners sp. nov.

Pl. 11, figs. 8–8c.

Specific Characters.—Of moderate size with long neck; hyaline in colour. Rostrum very long and narrow; lamella single. Antenna very long, one-fourth longer than neck width. Teeth three, fairly large and uniform. Lumbar region heavy. Foot

very short, of three segments. Spurs fairly long, almost parallel. Corona one-half wider than collar. Oral entrance has a great projecting spout form. Upper lip very distinctive. Size, 1/80th inch.

This is probably a tube builder, but none was ever seen in a case. The older specimens were very sluggish and hardly ever moved from the place where they were first seen. They are far from being of the *musculosa*-type, as the trunk runs and streams into all shapes when feeding. At first I decided it was a Mniobia. In the first example observed the foot was planted against the cover-glass and the spur segment was seen to have a slight expansion at the end (Pl. 11, fig. 8c). There seemed to be clusters, two or three, of very fine muscular sucker-like threads from the end and no sign of toes. Later, however, a young specimen was observed creeping against the cover-glass, and showed toes very distinctly, two well spread out, and evidently a smaller one though not well distinguished. It progressed at rather a slow rate, with a rasping dead pull. The pre-intestinal part appeared fully as long as the rest of the body.

The rostrum is somewhat of the nature and appearance of that of *Rotifer longirostris*. It is as long as the width of the neck, and is very narrow and of practically uniform width. The joint in the middle is very distinct. In the older specimens when attached, the rostrum has generally an empty appearance, and the sheath is peculiarly mica-like. The skin of the neck occasionally has this wrinkled mica appearance; when young the neck is fleshy, and the rostrum lacks much of this appearance. The young was seen to bend the rostrum at right angles to the body, and to twist it about easily, as if it were fitted into a socket. The lamella is single and spoon-shaped. The inclosed wheels are elongated. The antenna is very long—one and one-fourth times the neck width—and it is very narrow from the joint to the end; and has a stout bunch of setae in the middle of the extremity.

The antennal segment is longer than usual. Behind the antenna, and not alongside, are two peg-like projections, apparently cone-shaped in one view, and triangular in another. They rise direct from the segment with no ridges or connection between them. *H. ampulla* has similar prominences. The jaws are long and rather narrow, and bear three teeth on each side, fairly large and uniform in size.

There is a large and round intestine, and the contractile vesicle is rather small and of short period. The short foot consists of three segments. Spurs are of moderate length, slightly shouldered on the outside at the roots, and then proceed downwards with a slight convex curve. They are not divergent.

The corona is a very pretty one, with strong cilia which play to a considerable extent into the great oral entrance. In some views it reminds one of some lily in bloom with its long stalk and bulb ; the long rostrum and antenna standing out well, almost at right angles, contribute to the elegant outline. The corona is to the collar as 9 to 6 and is much inclined ventrally. When the neck is bent dorsally, till the plane of the wheels is horizontal, the ventral view shows the great oral entrance-spout standing straight up, and well above the level of the wheels (Pl. 11, fig. 8b). This large spout-like mouth is very similar to that of *H. angusticollis* (2).

The upper lip is a thin-looking, glassy, laminate plate, rising well up, broad and curving slightly outwards, and crowned with a flat triangle.

When the neck is bent, rings are formed simulating joints, and even in the rostrum a false joint may appear. When the animal is contracted into a ball, the head is seen attached to the front of the trunk by about a score of delicate muscular threads, parallel and stretched like piano strings.

A yellow case was seen frequently, and only where this animal was found; empty, except in one instance when there was an egg inside. I did not see it hatch out, but soon after it did I found a half-grown specimen on the slide, which I had not observed before, and which probably came from the egg. The case is almost round in shape, and has no neck. It has a hard thin wall with granules in it, and there are about a dozen rings or bars projecting on the inside, looking like lines of latitude on a globe.

Habitat.—Draaifontein farm ravine pools. Found in fair numbers, on different occasions, but only from the one place.

Habrotrocha valida sp. nov.

Pl. 13, figs. 16–16a.

Specific Characters.—Of small size, short and very stoutly built. Hyaline in colour, but older ones occasionally have the stomach coating slightly brown. Rostrum short and thick;

lamella single, undented. Antenna about one-fourth neck width. Teeth large, six. Foot short, stumpy, of probably four segments. Spurs very short cones without interspace. Corona is narrower than the collar ; sulcus a mere slit. Upper lip rises to the top of corona, large, with a broad straight front margin and a parallel distinct ridge well back. Size, up to 1/100th inch.

This is quite a handsome sturdy little animal. It is fleshy in appearance, and the distinction between the segments is not always easily discernible. It is a voracious little creature, and soon the dozens that may be seen in a slide settle down to feed, and very quickly the trunks assume barrel-like forms, so that when they then creep they have a trussed-fowl or penguin-like appearance. The shape when feeding is characteristic, all being alike. It is a fast traveller with a long stride, but usually it moves about very little, and remains very quiet for long periods when feeding, and is not easily disturbed. The rostrum is stout and the lamella is single and undented, transparent and almost semicircular. The dental bulb is comparatively large, and the six closely set teeth can be readily seen.

The lumbar plicae are not very prominent. There are heavy foot-glands, and the spurs are very short, non-divergent and without interspace. Each has a very broad base, and quickly narrows to a sharp point, with a straight line, or barely perceptible double curve on the inner border.

The corona is small and has very short pedicels, and the outline does not narrow in, on the lateral borders. There are two little prominences on the wheels close to the sulcus ; these seem to be small loops, or swellings on cords or ridges from the wheels, running down over the inside edges just into the sulcus, which is a mere slit. The corona is to the prominent collar as 5 to 7. The upper lip rises, practically, to the top of the sulcus, with a very broad, straight front margin, and there is a band or ridge parallel to the front margin, and well back. This ridge seems to rise up from the lateral borders of the upper lip. Both ridge and front margin look bluish green while the rest of the lip is colourless.

The egg is an oval, equally rounded at both ends and smooth.

Habitat.—Ground moss, Stellenbosch. Very abundant from the one place only. Dozens were sometimes seen on a slide.

Habrotrocha alacris sp. nov.

Pl. 12, figs. 14–14a.

Specific Characters.—Very small and narrow; hyaline. Rostrum long and narrow, with double lamella. Antenna stout, about three-fourths neck width. Jaws large with two large teeth. Rump distinctly marked off from the trunk. Spurs short cones. Corona is wider than collar. Seta on pimple on each wheel. Sulcus equal to half the width of wheel. Upper lip a small rounded segment on a flat curve. Size, 1/120th inch.

This little animal creeps fairly fast, but steadily and without slithering. It assumes very graceful curves when feeding.

The dental bulb is large, and with its muscular investment takes up, practically, the whole width of the segment. The two teeth are also quite large. The trunk is very plicate. There is a distinct marking off of the anal and pre-anal segments from each other and from the trunk. The intestine is large and elongated, but the contractile vesicle is small. Spurs are equal to the ankle width, divergent and without interspace.

The corona is fully one-fourth wider than the collar, and the pedicels are very long, so that the general appearance of the corona is a little like that of *H. eremita* or *H. acornis*; only the distance between the pedicels inside does not increase upwards, and the distance from the sulcus bridge to the top of the corona is comparatively greater. There is a small round knob—not a ligule—on the sulcus bridge. The semicircular upper lip rises just up to the sulcus bridge; and the collar, above which there is a lateral expansion, shows very prominently.

Habitat.—Ground moss, Springfield, Uitenhage district. Not common and found only in moss from the one place.

Habrotrocha elusa sp. nov.

Pl. 11, figs. 9–9a.

Specific Characters.—Of moderate size, rather stoutly built but not swollen looking; keeps its shape well. Of a brownish to dark lemon-yellow colour. Rostrum stout, lamella double and prominent. Antenna short, equal to one-third neck width. Teeth six. Skin smooth and thick. Shape of rump and first segment of foot very characteristic and constant. Spurs two

short cones, with flat interspace. Stippling heavy over all trunk and foot, first segment of foot heaviest of all. Corona fully equal to collar; sulcus very narrow. Upper lip large, right to top of corona, with a small notch in front. Size, up to 1/75th inch.

This is a stout and very symmetrical animal with thick, leathery but smooth skin. It is of the *musculosa*-type as regards the quick response to the action of the muscles, so that in whatever position it is the shape for that position is practically constant. The neck is extremely stout and fleshy, and its outline is made up of three graceful curves not broken by the joints.

The corona is fairly large, but is rather difficult to measure. My measurements are, corona to collar as 9 to 9 up to 10 to 9. The average would be about 10 to 9½.

The rostrum covers a large part of its segment when tossed back. There are six teeth on each side of the dental bulb, three large and three small. The small teeth are difficult to count, but in the instances where I could count them the number was three. The trunk is fleshed right up into the ridges, and shows dense round the borders, where a considerable depth of skin is seen owing to the boundary bend. This dense leathery shell or rind-like part contrasts with the interior, and has a dark-greenish tinge, like that described in *Otostephanos regalis*. It often acts in the same peculiar way as *O. regalis* when, having stopped creeping with the intention of feeding, as shown by the working of the jaws, and as if too timid to decide, it starts a panting sort of action with a queer little shake of the head up and down, and may continue this for a long time, before it unfolds the corona. When it feeds, the head is kept very steady, and the foot is generally hidden under the rump.

The form of the rump is constant. There are three folds of the thick skin on each side bulging out between the joints, or apparent joints. The middle one looks something like the prominence shown in the figure of *H. crenata* (Murray) (2, 3). All the rump—bulges included—is heavily stippled or granulate. I have never seen any crenate appearance even on the first segment of the foot, which is the most heavily granulate part. Evidently the granules are under the skin. The foot has four segments; the first is stout and curves out very delicately till past the middle, and then curves inwards much more quickly.

The second segment is much narrower and very short, and seldom much seen. Young specimens have seldom any colour, but can be identified by the foot. There is no boss on the foot; the elegant dorsal curve of the first segment is quite unbroken, though there is a thickening under the skin, like that described in *H. torquata* (8). The spurs are short cones often stippled, very divergent, with a straight fairly wide interspace. Occasionally the under border of the spurs may be seen in a straight line with the interspace. The contractile vesicle is large, and flattened posteriorly.

The egg is large, smooth and oval in shape, equally broad at both ends.

I have known this animal for many years and have spent more time examining it than any other species. For a long time I was unable to form definite conclusions about some points, and not until it was noticed that there were two species not very unlike in several details. The second one, which turned up occasionally with *H. elusa*, is paler and more lightly stippled, but for some time I thought that the type varied and included both.

H. elusa is not sluggish, and when put on a slide creeps about a great deal, and usually takes a long time to settle down to feed. After hours, it may be, one may stop and feed for a short interval and then resume creeping. It may be the second or third day before it begins to feed steadily, and then it does so very quietly, and in a characteristic position. If there be a bit of green moss about, *H. elusa* is almost certain to take refuge on or below it, and remain there. It is then almost impossible to get it clear. I do not think I have ever noticed it take refuge under withered moss. It feeds very freely on or under the moss, but there, of course, it is not possible to observe it clearly. It is also found feeding quietly in the open. I have often taken notes of one creeping and been unable to see it feeding during the same sitting. Before the next examination the specimen had probably retreated to the moss, or could not be found feeding. Then perhaps what was taken to be but a paler example was found feeding, and a sketch made, which when compared with former sketches usually showed some difference, especially as to upper lip and spurs. I changed my opinion several times with regard to these until I distinguished between the two species. A difficulty was, that one or the other was often not to be found when

wanted for comparison. Afterwards it became quite an easy matter to distinguish between the two, creeping or feeding.

H. elusa generally feeds with its head above the horizontal, and the tip of the upper lip is not then seen projecting at the front, but lies over the narrow sulcus, which usually shows a black space owing to interference, when practically no details can be made out. When the head is exactly on a level with the body the peculiar nature of the upper lip may be seen, but as a rule it requires much patience and needs much searching before one is observed feeding at the right angle. The lip is fairly broad in front with a small notch in the middle. Laterally there is a fold, from the top corner to some distance down, turned in over but not quite down on to the rest of the upper lip, leaving a space below running into the corner.

The rump is very distinctive, with the triple folds of skin on each side. The middle one is the largest and recalls *H. crenata*, but the prominence in the latter does not seem to be a wide fold of the skin—from the description—and is stated to be clear of stippling, whereas the folds in *H. elusa* are heavily stippled like the rest of the rump.

The first segment of the foot is sufficient to distinguish *H. elusa* from other species.

I do not think I have ever seen *H. crenata*, but there is evidently a resemblance in its general outline to that of *H. elusa*. The different type of upper lip, however, is alone enough to show that the two are distinct species.

H. elusa differs in many points from the description of *H. crenata* by Murray.

The corona of the former is proportionately much wider, and the front margin of the upper lip is quite different, having a notch.

It has a decided colour, whereas *H. crenata* is colourless.

It never has a crenate appearance, and the stippling is most pronounced on the first segment of the foot, while in *H. crenata* it diminishes on the foot.

The rump has three folds of thick skin and all stippled. In *H. crenata* there is but one round prominence, which is stated to be free of stippling. *H. elusa* has no boss on the foot and its spurs have a straight interspace. The inclosed discs are large. The egg is not narrowed at the anterior end. *H. elusa* is not

sluggish. Murray does not mention *H. crenata* as having been found in South Africa. If it had been as common as *H. elusa*, I think he was certain to have seen it.

Habitat.—Ground, rock and tree moss, Uitenhage district (all over), Umtata, Somerset East and Grahamstown. Very common.

Habrotrocha elusa var. *vegeta.*

Pl. 12, fig. 10.

Specific Characters.—Active, rather small, colourless. Antenna short. Neck stout and fleshy, with same outline as *H. elusa.* Teeth three large and four small ones—possibly more. Trunk plicate ; stippled, as are also the rump and foot. Rump fairly heavy, without prominences. Foot of four segments ; first segment long with straight borders. Spurs short cones without interspace. Corona less than collar. Upper lip narrow, rounded in front and with a slight groove. Size, 1/90th inch.

This jaunty little animal creeps fast with a short glide. It usually does not take long to settle down to feed. It can be kept healthy for a long time in a slide, and is generally seen actively feeding. Its manner of feeding is very like that of *H. plana.* It suddenly glides a step and is feeding again with startling rapidity, and keeps on repeating this performance at short intervals ; but also it may remain feeding in one position for a very long time. The head is sometimes kept very steady, but usually is drawn very slowly up and down, or round and back.

The upper lip is more difficult to observe than that of *H. elusa*, being narrower at the front, and hardly projecting over the sulcus. I only once or twice got a really good view, such as made clear the details. Nearly always the blackness due to refraction in the sulcus obscures the parts. The tip is bent downwards, and there is a cross line or ridge, a little back. From the middle of this a minute groove proceeds to the front ; but it would appear as if the groove does not penetrate very deeply into the substance of the upper lip, and probably does not reach the bottom at the tip, so that at certain angles no gap is seen in front, while at others a minute gap appears.

It nearly always feeds fully extended.

I find this animal in fair numbers in Aberdeenshire.

The chief differences between it and *H. elusa* are : The glide

when creeping; the want of colour; the corona is, proportionately, decidedly narrower; rump has no prominences; foot has plain, straight outline; spurs have no interspace. It feeds with neck and foot fully extended, whereas *H. elusa* lies over the foot, and always has the neck partially retracted, so that each segment shows decidedly wider than the one in front.

Habitat.—Ground and tree moss, Umtata, and Uitenhage district.

Habrotrocha tranquilla sp. nov.

Pl. 12, figs. 11–11a.

Specific Characters.—Large and shapely; stoutly built. Rostrum stout with prominent double lamella. Antenna short, about one-third neck width. Dental bulb large, oval. Teeth seven. Trunk plicae well marked. Rump fairly heavy, narrows quickly to foot. Foot narrow and short, of four segments. Spurs sharp cones, divergent, and without interspace. Corona slightly wider than collar; sulcus narrow. Upper lip projects over the sulcus, and has small gap in front. Size, 1/60th inch.

This is a large handsome animal, and occasionally shows the merest tinge of colour. The trunk is very long, and when feeding swells out like a muscular sack; the pre-intestinal part is comparatively short, and the post-anal very short. The posterior of the trunk and the rump are eccentric, raised dorsally, so that, if the toes miss the catch, the posterior swings round, and at times, when well fed, it seems compelled to shoot out the foot sideways.

Of the seven teeth, four are large and three very small. The corona to collar is as 13 to 10. The upper lip is fairly broad at the top and has a small gap. It projects over the sulcus, but not quite so high as the outside parts of the wheels. The upper half is almost oblong, and then the border bends quickly, in two curves, to the collar. The front margin is somewhat like that of *H. elusa*, but the details are more easily made out.

I find this species in Aberdeenshire with slight variations. The corona is slightly narrower, and I counted nine teeth. There was a boss on the foot. I might, however, have overlooked this characteristic in the South African species, as I did not pay much

attention to bosses at the time I found it. Otherwise, the two agree extremely well.

Habitat.—Rock moss, Kamaehs farm, Uitenhage district.

Habrotrocha pertinax sp. nov.

Pl. 12, figs. 12–12a.

Specific Characters.—Very small, narrow at front and widening gradually to the rump; hyaline. Rostrum narrow with prominent double lamella. Antenna short, about one-third neck width. Teeth three to four, quite large for pellet makers. Rump heavy. Foot of apparently three segments. Spurs sharp cones, divergent, no interspace. Corona to collar as 4 to 7½. Sulcus a mere slit. Upper lip a broad mass rising right up, and projecting slightly over back of wheels. Trunk clearly stippled. Size, 1/120th inch.

This is an active little animal. It keeps on for a long time creeping fast with a slither or glide, sometimes for hours without resting. It is so small that it is quite easily overlooked, and when searching particularly for it in a new slide I hardly think I ever found it, as it apparently keeps out of sight in the debris, or rolls up in a ball after being disturbed. Only after a day or two, when examining the slide, by chance one might be caught sight of in the open.

The corona is scarcely more than half the collar width. When the head is thrown back it has the appearance of *Scepanotrocha* (5), as then the edges of the wheels just show above the big upper lip. Seen horizontally, the upper lip is a broad mass right up to the top of the corona, but seems to turn slightly in at the middle. The edge of the upper lip, rising up from the collar, seems to just pass over the back of the wheels, and to form a sort of cradle for the back of the corona. When it is feeding —lying on its back—with the head bent up above the horizontal, the square, broad outline of the upper lip can be seen just above and behind the wheels, also the part mentioned above appears triangular in outline over the wheels. It usually stands straight up on its toes when feeding, and keeps in one position, or very slowly turns its head; it keeps stretching and stretching till sometimes the length is considerably greater than the creeping

length. It may keep on feeding for a long time, and different views are obtained as it turns its head, but being so small the details are not easily made out. There is no play of cilia dorsally, but a great flutter round the pedicels towards the oral entrance, and straight up above the corona.

Habitat.—Ground moss, Springfield. Only seen from one place, and, from the number actually seen, apparently fairly abundant.

Habrotrocha gulosa sp. nov.

Pl. 13, figs. 15–15b.

Specific Characters.—Of fairly large size; hyaline in colour, except that the pellets are usually bright yellow or green. Rostrum stout and long. Antenna as long as one-third neck width. Teeth three, fairly large. Anal segment long, with large contractile vesicle. Foot slender and short. Spurs short cones with fairly straight interspace. Corona as wide as collar, with narrow sulcus. Upper lip a wedge rising from a flat curve. A seta with a bulbous root on each wheel. Trunk heavily stippled. Size, 1/75th inch.

This is a gluttonous animal, and in a very short time, when feeding, becomes crammed with pellets. It is heavy towards the end of the trunk and lumbar region, and when well fed becomes very much so, and penguin-like. When it begins to creep after a heavy meal, its balance is so disturbed that on letting go with the toes the lumbar region swings round, and the toes catch on the right or left as the swing allows, and are occasionally pulled quite up by the trunk falling right over to the one side or the other. It is a laborious business on such occasions for it to progress. At times it creeps fairly fast with a glide. When feeding it sometimes starts off swimming at tremendous speed, and may keep this up for some time.

The inclosed discs show a bold clear outline. I could not make out more than three segments in the foot.

The corona bears strong cilia which vibrate swiftly, and often make quite a haze round the wheels. The under lip is of a blunt spout-like shape, and projects a fair distance. The upper lip is often hidden by the rostrum, and is quite peculiar in shape.

A narrow wedge-shaped ridge rises up from the middle, just on to the sulcus bridge. This ridge is not straight up and down, but bends in with a sharp curve, at the top, over the sulcus bridge. The sharp edge of the wedge is dorsal, and curves round over the top, so that looking down dorsally, with the animal horizontal, a sectional view of the top of the wedge is got, looking like a very short stout ligule, apparently on the sulcus. It was thought at first to be a ligular process. Seen from the side the wedge shows broader (fig. 15).

The egg is ovoid, both ends broad and equal.

Habitat.—Ground moss, Uitenhage commonage (Mosel Road) and Springfield. Fairly common.

Otostephanos gen. nov.

Type.—Otostephanos auriculatus (Murray) = *Habrotrocha auriculata.*

Generic Characters.—Bdelloida having a ring of fair thickness round the corona with short breaks dorsally and ventrally.

Whether the ring is real or false, the appearance is so distinctive that there is no difficulty whatever in identifying a species as belonging to the group, after one is once known. It is easy enough, with the 1 inch objective, to distinguish whether a corona is ringed or not, even if it be one whose diameter is only 1/900th of an inch.

Bryce (8) is of the opinion that the ring is a ghost one. Murray (7) thought it real; to me it seems real enough. I cannot satisfy myself that the explanation that the ring is due to interference is sufficient, as for one thing there are many coronae which have no rings, whose disposition of the primary and secondary wreaths appears in nowise different from that of those which have. Also, as Murray states, there is no trace of motion in the ring, and the outline can be very clearly defined.

There is difficulty also in accepting the ring as real. From the lateral ear or loop appearance the ring seems to stand clear of the corona, but the ring possibly has a connection through a transparent membrane, the ring itself only being visible on account of its thickness. The ring seems close to and connected with the corona alongside the sulcus and also at the dorsal break.

Otostephanos regalis sp. nov.

Pl. 14, figs. 19–19b.

Specific Characters.—Large; of a lemon colour generally. Rostrum stout and long. Antenna fully equal to half neck width. Dental bulb long and narrow, with six teeth. Heavy rump and short stout foot of four segments. Spurs short cones. Trunk deeply plicate, and stippled. Corona about one-fourth wider than the collar; sulcus narrow and shallow. A seta on each wheel. Upper lip a semicircle set on a base with a ligule on the top. A steady feeder. Size, 1/65th inch.

This is a large, powerful animal. It is a swift creeper, and a bold feeder in the open; and is very symmetrical, with a distinctive shape both creeping and feeding. It is of the *musculosa*-type and recovers its bold curves and lines almost instantly, not sagging anywhere, as the leathery skin is thick and elastic. Focusing down to the middle-depth of the trunk, the outline, owing to the depth of skin under view all round the margin, stands out with a dark-greenish shade on account of its density, and shows like the rind in a sliced citron fruit. The circular muscles are very distinct.

The colour varies, usually lemon all over—deepest in the ovary—but sometimes of a pinkish yellow. The trunk, rump and foot including the spurs are heavily stippled, the first segment of the foot more especially so.

Corona to collar is as 12 to 9½. On each wheel is a short seta with a bulbous base on what looks like a raised cone, but is evidently a triangular ridge across the wheel. The setae are inclined towards each other. There is a rosette round the closed mouth.

The ring in *O. auriculatus*, Murray (7), is stated to have a break or gap laterally. There is an apparent gap in the ring of *O. regalis*, but not a real one. The lower part projecting from near the collar (dorsal view) does not belong to the ring, but is the secondary wreath or rather the base supporting it; and if it were continued through the apparent gap, would form a continuous curve with the upper part, and thus accentuate the idea of a break. The lower part (secondary wreath) is not a broken line, but bends back almost on itself, or at most at a sharp angle, and

then across to the oral entrance. The upper part of the ring comes down to near the bend of the secondary wreath and continues close, past and above it. When a slightly more ventral view is had, the two can be seen alongside each other for a short distance, but the continuation of each curve in its own direction gradually separates them.

The ventral view (fig. 19b) shows the real relative positions of the lines well. The ring rises from the hollow below the shallow sulcus, and can be followed round to the apparent gap, as can also the base on which the secondary wreath is situated. The two seem to approach each other towards the gap.

When the head is hanging down, well below the horizontal, the three planes—top of corona, ring and secondary wreath—can be seen projecting, one behind the other.

The upper lip is like no other I know. It shows like a clear transparent semicircle, with a metallic sheen, set on or rising from a flat curve from the collar. A stout peg-like ligule rises from the top and is always present. The rostrum has its segments marked very clearly, and the double lamella is very transparent and sometimes not very well seen, though quite large. There are several long setae and one or two thicker ones with bulbous roots. When tossed back the rostrum stands up perpendicular to the segment as a great mass and covers nearly all the segment; the cilia are generally in motion.

The dental bulb is long and narrow, and carries three larger teeth and three, possibly four, very small ones. The first joint in the neck posterior to the oral entrance is scalloped or serrated roundly, ventrally; and the anterior of the second trunk segment has a similar appearance.

The pellets are occasionally seen fairly large, but generally quite small, and at times can hardly be distinguished in a thick glairy mass. The foot is very short; the first segment is heavily granulate, the second is scarcely noticeable, so short is it. The spurs are slightly divergent short cones, but in one or two large examples the inner borders showed a slight double curve. There are heavy glands right up through the foot.

When settled and about to feed, it has a very peculiar quick, panting sort of action, with a queer little throw-up of the head, the jaws working all the time. It may keep this up for some seconds before unfurling the corona.

Habitat.—Rock and ground moss, Kamaehs, Springfield and Euphorbia Kloof in Uitenhage district. Fairly common.

Habrotrocha torquata Bryce I have never seen, but from the description take it to be one of the ringed group, and so it falls under the designation *Otostephanos torquatus*.

There is a ringed one, very common in South Africa, similar to the above but differing in the upper lip. I shall describe it as a variety.

Otostephanos torquatus (Bryce) var. *amoenus*.

Pl. 14, figs. 20–20a.

Specific Characters.—Of moderate to small size; spindle-shaped; trunk slightly grey, or bluish, transparent. Rostrum long and fairly stout, has a very long seta on each side at right angles. Antenna equals one-half neck width. Teeth very small, seven, possibly more. Trunk plicate and finely stippled. Fairly heavy rump, and short foot of four segments. Spurs, short cones. Corona is equal to the collar; sulcus very narrow and shallow. Upper lip has three blunt points on it. A seta on each disc. Size, 1/85th inch.

This animal generally creeps about a great deal at first, when put in the slide, but eventually settles down to feed very quietly. It is not a very fast creeper, and occasionally seems to have to rasp its foot from the glass with a steady pull. The rostrum has several setae under the lamella, and there is one on each side at right angles to the rostrum, fully longer than the width of the rostrum. Though pliable, they were not distinctly seen to be motile. I think these setae cannot be borne by *O. torquatus*, as Bryce was hardly likely to have overlooked them if present. The neck is stretched out when feeding, and generally with the head bent up.

The dental bulb is small, and the teeth are so small that they are seldom distinguishable at all with a 1/6th inch objective, when the animal is feeding. The rump is fairly heavy and distinctive, and the first segment of the foot is also distinctive, the sides being curved. The spurs have no interspace.

After some experience, it is not very difficult to identify the creeping form. *H. placida* has a general resemblance, and is often found feeding with it, but one has only to look for the

long setae at right angles to the rostrum, which if present indicate the variety *amoenus*.

The upper lip almost curves down for some distance from the collar, then turns quickly upwards with a graceful curve to the fairly broad front, which, when the head is on a level with the body, shows three minute knobs. When the head is raised somewhat, a rounded part is seen in front, and also the triple part above and behind it. The upper lip does not lie flat on the corona, but stands up at a considerable angle, so that the rounded part mentioned above may be the under side of the lip raised up and backwards so as to come into view; or, as I have sometimes thought, there may be two parallel membranes, the front one plain and the back one with the triple top.

The setae on the middle of the wheels turn outwards, while in *O. regalis* they turn inwards.

The inclosed wheels have a clear-cut border, forming a single oval, with practically no trace of the usual double appearance.

Habitat.—Rock and tree moss, Uitenhage district and Stellenbosch. Abundant.

Otostephanos monteti sp. nov.

Pl. 14, figs. 21–21a.

Specific Characters.—Of small size, short, plump and fleshy; of glaucous colour, with at times a very slight yellowish tinge. Rostrum short and broad, with prominent double lamella. Antenna very long. Dental bulb elongated, with eight small teeth. Foot of four segments. Spurs, cones of moderate length. Corona equal to collar, shallow, with prominent ring. Sulcus a mere slit ventrally. Upper lip, rectangular with a ligule-like extension on upper border. Size, 1/100th inch.

The two species last described are moss dwellers, but this one inhabits pools. It is a rather slow creeper and has a laborious movement of the foot, but plants it well forward; it seems to have a difficulty in attaching it to the glass. This animal is most irritating when feeding. As soon as the wheels are out, it begins whirling round and round on a vertical axis, at great speed, and continues this for many minutes at a time, then suddenly with a furious dart it swims clear away. Only once

did I see a specimen feeding quietly with toes affixed, and that not for very long. On several occasions I was hopeful of getting another view, but hardly had feeding commenced when the gyrations were once more started, before anything could be clearly seen.

It is of a sturdy build. The neck is very stout and fleshy, showing no lacunae; and the throat is wide and long. The inclosed wheels are a large clear mass, nearly circular in shape, with a small break in a clear definite outline. The closed mouth shows a well-marked rosette.

This is the only ringed form yet observed which has a very long antenna. It was not noticed for some time that the antenna was long, as seldom or never does it seem to have it at full stretch when creeping. When attached to the cover-glass and about to feed, and moving the head forward preparatory to unfurling the corona, the antenna is pushed straight in front, and when at full stretch is well ahead of the rostrum; and when the wheels are out it is seen projecting for a considerable distance in front of the wheels and straight over the sulcus. It has been seen extended to fully one and one-fourth times the width of the neck. When the animal is whirling round and round, the antenna is held outwards, with the end curving backwards, and gives a fleeting glimpse, reminiscent of a pump handle, as it swings round. Of the two segments of the antenna, the front one is not much shorter than the basal one, and the front end with its brushes of stubbly setae is very trident-looking. There is a large brain mass. The jaws are long and somewhat oval, and bear eight small uniform teeth.

The foot is stout and proportionately long, and consists of four segments. The spurs are less than ankle width, scarcely divergent and without interspace.

The corona is equal to the collar in width, and rather shallow. The collar is high up but does not protrude, and there is no narrowing-in of the neck from the collar backwards.

The upper lip is a low rectangle with rounded shoulders; and in the middle in front, extending up as a prolongation, is a long spike with a broad base, which gradually attenuates to a sharp point near the top of the corona.

This animal is easily distinguished from *O. torquatus* var. *amoenus* by its long antenna, stouter build and its habits when feeding.

I believe this is the same animal as the one described by Mlle. Montet (9) as a variety of *H. torquata*, but left unnamed.

Habitat.—Draaifontein ravine pools. Abundant.

GENUS PLEURETRA Bryce.

Pleuretra reticulata sp. nov.

Pl. 13, figs. 18–18a.

Specific Characters.—Of small size, widest near the middle and tapering to both extremities. No spines on anterior border of trunk. Dorsally, four transverse rows of spines on trunk, also one pre-anal and one anal. One row ventrally near front of trunk and two spines farther back. Rostrum has very long setae, especially two laterally projecting ones. Antenna stout, about three-fourths of neck-width, with long setae. Teeth two. Foot of four segments, narrow, with boss on first segment. Spurs distinctive. Transverse ventral ridges nine or ten. Corona to collar (minus flaps) 10 to 12; sulcus narrow with sharp peg-like ligule. Upper lip rounded with a notch. Stippled. Size, 1/120th inch.

After examining this species carefully in 1914, and on looking over some older notes, I found a set which I had completely forgotten on this very animal. Thus I was furnished with a good opportunity for comparison, all the more fortunate in that the spined species are notoriously variable. Evidently this is a very stable form, as the sketches are practically identical. It resembles *Macrotrachela aculeata* in shape, and differs from the other spined species in not having the clumsy rump. Its shape is elegant in all positions, and the spurs, which are always seen when it feeds, finish off the appearance well. It is beautifully stippled over trunk, foot and spurs.

At times it creeps quite fast with a glide, and moves more quickly than the other spined species.

The anterior border of the trunk has no spines. The trunk has four dorsal cross rows, with eight spines each in the first, second and fourth rows, and nine in the third. There are four spines on the pre-anal segment and four on the anal. Just above the last two rows of spines there is, in each case, in the middle of the segment, a double blunt short thorn. The ventral row consists

of six spines plus two large lateral ones, and is situated on the first segment of the trunk and about the middle of it. The other two ventral spines are near the sides and opposite the first dorsal row. In one set of notes it is stated that the two front rows are incipient, just as if the bends of the ridges had grown out to points. The other rows are similar but more developed.

The rostrum is long with a fairly prominent double lamella. The setae are long, and noticeable when feeding; two from the corners are long, and like those of the variety *amoenus* (p. 173). The brushes of setae in the antenna are about as long as the antenna itself. There are two plates alongside the antenna. The dental bulb is rounded with a quadrate upper margin, and the two teeth are not far from the middle. The transverse ventral ridges have a wavy appearance, more especially the first. The spurs are longer than the width of the ankle, divergent and decurved, almost sickle-shaped.

Each wheel in the corona bears a seta, and these two setae cross each other in every case. The ligule is always present and is a very short peg-like structure. The upper lip rises just over the sulcus bridge, and is broadly triangular with a rounded front margin, slightly notched. There are two ear-like flaps from the lower lip, quite abnormal in size.

The longitudinal ridges are wavy and help to give a reticulated appearance to the animal. The skin is not hardened nor suggestive of a lorica. Apparently there are only three toes. The opening of the sheath from which the toes protrude is round and very small. When resting against the cover-glass, only three toes can be seen and they appear to fill up the whole opening. The back one may bifurcate, but I could not trace any sign, as the toes when planted on the glass are unfortunately always in the shadow of the trunk, and being so small cannot be well seen. I never could get a proper side view of them.

The egg is broadly ovate and symmetrical, with sixteen or seventeen small swellings, giving it a wavy outline. The spines and ridges are visible in the egg, before the hatching takes place.

I found one specimen in Aberdeenshire which agreed extremely well in all particulars with the South African ones. It gave the same suggestion of three toes.

Habitat.—Ground moss, Draaifontein and Springfield, Uitenhage. Fairly abundant.

Genus SCEPANOTROCHA Bryce.

Scepanotrocha galeata sp. nov.

Pl. 13, figs. 17–17b.

Specific Characters.—Of very small size ; very slender. Creeps fast with a glide. Narrow rostrum, with single spoon-shaped lamella. Antenna stout, very short, about one-third of the very narrow neck. Dental bulb small, rounded, with four or five teeth. Trunk deeply plicate ; lumbar region long. Foot moderately long, apparently of four joints. Spurs of moderate length, divergent, without interspace. Upper lip a heavy mass, broadest at upper margin. Size, 1/130th inch.

This is another very small species, only likely to be noticed when in a favourable position. The most noticeable feature is the overgrown helmet-like upper lip, which is broadest at the upper margin, the front being straight or a very flat curve. Round and towards the front the upper lip is thick.

The wheels could never be clearly made out. The wheel-whirl is all in front and in a vertical direction. Only a very indistinct or hazy view of the wheels can be got through the flare of the cilia, but they seemed to be very small, possibly about two-thirds of the collar. Only from one view did I get the impression that the wheels were in the usual position. The indications on the whole were in favour of the wheels being at a very considerable angle to the usual position.

Sometimes there was an appearance as if there were a thin laminate part between the upper lip and the wheels. It is a dapper little fellow, and feeds usually with the neck bent gracefully, and holding the head well up in a gallant way. When creeping, the neck shows three gentle curves on each side.

Habitat.—Rock moss, Euphorbia Kloof, Uitenhage. Rare.

Genus MNIOBIA Bryce.

Mniobia animosa sp. nov.

Pl. 12, fig. 13.

Specific Characters.—Of moderate size ; spindle-shaped. Rostrum fairly stout. Antenna broad, very short, about one-fourth neck-width, with a prominence on each side of it. Front of dental segment wide. Dental bulb small, with three large well-

separated teeth. Lumbar region fairly heavy. Contractile vesicle fairly large. Spurs short. Foot short, of five segments. Corona equal to collar. Upper lip a triangle. Deeply stippled. Size, 1/80th inch.

This is a rather keen-looking, graceful animal when feeding, and generally feeds with the foot extended. It is deeply stippled from and including the dental segment down to the spurs. The front of the dental segment is wider than the part in front of it. The anal segment looks double. The foot is smooth, and short, though it has so many segments. Spurs are not very sharp, but are decurved so that they look usually very short and very blunt, like those of *Mniobia obtusicornis*. There is a swelling, longitudinally, along the first foot segment, which is short. The corona is to the collar as 8 to 8. The sulcus is equal to about one-third of the disc width. The upper lip is flat, rising abruptly near the middle into a triangle whose base is as wide as the sulcus.

Habitat.—Ground moss, Grahamstown.

Genus ADINETA Hudson.

Adineta cuneata sp. nov.

Pl. 14, figs. 22–22a.

Specific Characters.—Of large size, stout, hyaline. No setae or expansions on the rostrum. Antenna fairly long. Teeth two. Rump has no distinctive shape. Contractile vesicle large and elongated. Foot stout, of five segments. Deep constriction at ankle when foot is fully extended. Spurs short and at right angles to foot, with a large convex interspace. Toes stubby. There are large foot glands. Size, 1/75th inch.

Murray (7) was well acquainted with this animal and considered it a good species. It has a short hopping sort of motion, reminding one of the hop of a rabbit, when it is feeding and moving about slowly.

The only species near this is *A. vaga*. *A. cuneata* has a less elegant shape, and a slightly squarer head. It has a stouter foot and a segment more in it, and a narrower constriction at the ankle when extended, which gives a distinctive appearance to the spur segment. The part posterior to the spurs is shorter and the toes more stumpy in appearance.

The two are easily distinguished from each other, at a glance, by the shape of the spur-segment and the spurs.

Habitat.—Moss; very abundant all over Uitenhage district, and in other parts.

Macrotrachela quadricornifera var. nov. *rigida*

Pl. 14, figs. 23–23c.

Specific Characters.—Very large and strong; trunk black-brown in colour; skin extremely thick. Rostrum stout and fairly long, with double lamella. Antenna long and stout, equal to two-thirds neck width. Jaws very large; teeth two large and two small. Neck very stout. Trunk deeply plicate laterally. Rump very distinctive. Foot long and narrow. Spurs excised below. Corona bold and large; sulcus wide; a short seta on each wheel. Upper lip complicated. Deeply and beautifully stippled. Size up to 1/40th inch.

This is the animal mentioned in Part I (10) as possibly a variety of *Philodina childi*, and is very likely the same as the *Callidina quadricornifera* of very large size seen by Murray (4) in moss from India.

Since I wrote Part I, I have seen a few good specimens, found in moss sent me by Mr. P. Smith, Umtata. In all these I made a careful examination as to the nature of the back toe. The animal frequently crawls against the cover-glass, but it takes such long strides that one has usually to move the stage in order to see the toes planted; and as the foot is sometimes thrown to the side, and sometimes directly under, it is almost hopeless to try to anticipate where the toes will appear. The back toe has a double appearance, something like two blunt cones, sliced longitudinally almost to the middle and placed against each other. There was an appearance of muscles up each half, but there might have been up the middle also though not seen. I thought there might prove to be an incipient toe orifice at the end of each half, but was unable to detect any signs of it. The toe appearance varies in different specimens, but fig. 23*c* gives a fair average. When the toes are almost withdrawn, the orifice shows more like Philodina than Macrotrachela.

It is a quiet, slow animal, deliberate in all its motions, and can be kept in a slide for a long time. The chances are that

when the slide is examined at any time, it will be found either feeding freely, or completely contracted into a ball—less seldom will it be found creeping. It sometimes lies for so long a time contracted that one has difficulty in deciding whether it is alive or not. I once put one aside as dead, and on again examining the slide in which it was, for some other purpose, found it feeding briskly.

Its shape varies very little on account of the extremely thick skin. There is never a wrinkle in the trunk, only, when it sits back feeding, the trunk widens out, but the shape is perfect. It has a habit when feeding of pushing forward the first trunk segment towards the antenna, till it stands out like a frill.

The rump is the most distinctive part. It is not particularly heavy, and rises up—fairly flat across—for a considerable distance backwards, then dips sharply down forming an elbow ridge, which is practically rigid owing to the stiffened material bounding it. I have never seen the ridge obliterated, even when the foot is fully extended. Fig. 23*b* gives a side view.

The corona is large and graceful, and the wide sulcus equal to three-fourths of the wheel-width. Corona, collar and neck are to each other as 37, 22 and 18. There is a comb-like ridge which runs across the wheel, and extends well into the sulcus with a bold curve. The central part of the upper lip front margin (fig. 23*a*) is copied from the few samples lately seen, and is rounded; but in all the large number of specimens examined formerly, the central part is distinctly triangular with a sharp apex. The Grahamstown examples were rather smaller in size than the Umtata ones.

The dental bulb is extremely large—about 1/500th inch—and is surrounded by a heavy muscular mass. Two teeth are very broad, and two, one on each side of these, are smaller, about one-fourth the size of the others, but occasionally one of these is wanting or scarcely noticeable. There is a large granular gland behind the bulb.

The intestine is large and heart-shaped, and very thick walled. There is a distinct, narrow, button-like muscular cincture between the intestine and the stomach (fig. 23).

The spurs, on the first segment of the foot, are blunt and flat, and lie near each other.

The stippling is of the same nature as that of *Philodina grandis*

(10). The stipples are larger, but are arranged in the same manner, and have the same beautiful honeycomb appearance.

Habitat.—Tree and rock moss, Grahamstown and Umtata. Fairly numerous.

A good many other species of Bdelloida were examined sufficiently to see that they were different from any that have been hitherto described, but owing to some detail or other being absent from my notes I have not attempted to describe them. There was one dainty, pert little Macrotrachela, with a very distinctive antenna equal in length to three times the neck width, motile, and with a rhythmic beat in unison with the motion of the jaws ; found on weeds in running water.

I intended giving a list of all the Bdelloida I observed in South Africa, but find it impossible to do so at present. This list may appear as an Appendix to the above on some future occasion.

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Description of Plates.

Plate 10.

Fig. 1. *Macrotrachela verecunda*, dorsal, creeping.
,, 1*a*. *Macrotrachela verecunda*, corona.
,, 1*b*. *Macrotrachela verecunda*, antenna.
,, 1*c*. *Macrotrachela verecunda*, top of corona with view of upper lip.
,, 2. *Macrotrachela smithi*, dorsal, creeping.
,, 2*a*. *Macrotrachela smithi*, corona.
,, 3. *Macrotrachela timida*, dorsal, creeping.
,, 3*a*. *Macrotrachela timida*, corona.
,, 4. *Macrotrachela timida*, var. *inquies*, foot and rump.
,, 5. *Macrotrachela faveolata*, dorsal, feeding.
,, 5*a*. *Macrotrachela faveolata*, jaw.
,, 5*b*. *Macrotrachela faveolata*, spurs.
,, 5*c*. *Macrotrachela faveolata*, side view, large wart.
,, 5*d*. *Macrotrachela faveolata*, front view, large wart.

Plate 11.

Fig. 6. *Habrotrocha placida*, dorsal, feeding.
,, 6*a*. *Habrotrocha placida*, dorsal, creeping.
,, 6*b*. *Habrotrocha placida*, top of corona with upper lip.
,, 6*c*. *Habrotrocha placida*, corona, beginning to unfold.
,, 7. *Habrotrocha plana*, dorsal, feeding.
,, 8. *Habrotrocha iners*, dorsal, feeding.
,, 8*a*. *Habrotrocha iners*, dorsal, creeping.
,, 8*b*. *Habrotrocha iners*, corona, ventral, showing large spout-like lower lip.
,, 8*c*. *Habrotrocha iners*, spurs and toe segment as seen in adult against cover-glass.
,, 9. *Habrotrocha elusa*, dorsal, creeping.
,, 9*a*. *Habrotrocha elusa*, dorsal, feeding.

Plate 12.

Fig. 10. *Habrotrocha elusa*, var. *vegeta*, dorsal, feeding.
,, 11. *Habrotrocha tranquilla*, dorsal, feeding.
,, 11*a*. *Habrotrocha tranquilla*, dorsal, creeping.
,, 12. *Habrotrocha pertinax*, dorsal, creeping.
,, 12*a*. *Habrotrocha pertinax*, corona, dorsal.

Fig. 13. *Mniobia animosa*, dorsal, feeding.
,, 14. *Habrotrocha alacris*, dorsal, creeping.
,, 14*a*. *Habrotrocha alacris*, corona.

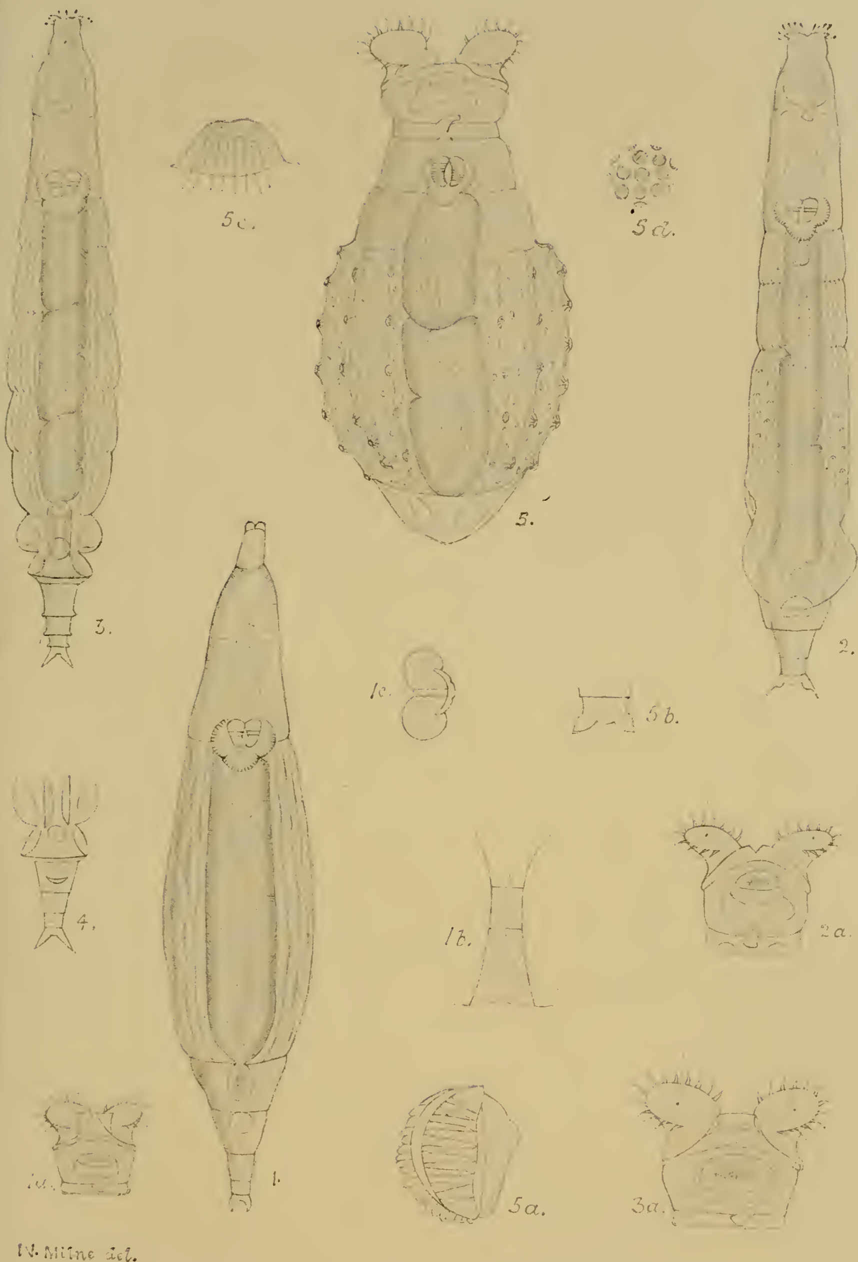
PLATE 13.

Fig. 15. *Habrotrocha gulosa*, dorsal, feeding.
,, 15*a*. *Habrotrocha gulosa*, dorsal, creeping.
,, 15*b*. *Habrotrocha gulosa*, side view, upper lip.
,, 16. *Habrotrocha valida*, dorsal, feeding.
,, 16*a*. *Habrotrocha valida*, dorsal, creeping.
,, 17. *Scepanotrocha galeata*, dorsal, creeping.
,, 17*a*. *Scepanotrocha galeata*, corona, dorsal.
,, 17*b*. *Scepanotrocha galeata*, corona, ventral.
,, 18. *Pleuretra reticulata*, dorsal, creeping.
,, 18*a*. *Pleuretra reticulata*, corona, dorsal.

PLATE 14.

Fig. 19. *Otostephanos regalis*, dorsal, creeping.
,, 19*a*. *Otostephanos regalis*, dorsal, feeding; stippling rather exaggerated.
,, 19*b*. *Otostephanos regalis*, corona, ventral.
,, 20. *Otostephanos torquatus* (Bryce) var. *amoenus*, dorsal, creeping.
,, 20*a*. *Otostephanos torquatus* (Bryce) var. *amoenus*, corona, dorsal.
,, 21. *Otostephanos monteti*, dorsal, creeping.
,, 21*a*. *Otostephanos monteti*, corona, dorsal.
,, 22. *Adineta cuneata*, head, dorsal.
,, 22*a*. *Adineta cuneata*, foot, posterior with spurs.
,, 23. *Macrotrachela quadricornifera*, var. *rigida*, dorsal, creeping.
,, 23*a*. *Macrotrachela quadricornifera*, var. *rigida*, upper lip.
,, 23*b*. *Macrotrachela quadricornifera*, var. *rigida*, rump, side view.
,, 23*c*. *Macrotrachela quadricornifera*, var. *rigida*, back toe.

Where proportional numbers are given in the text, each unit represents 1/6000th inch.



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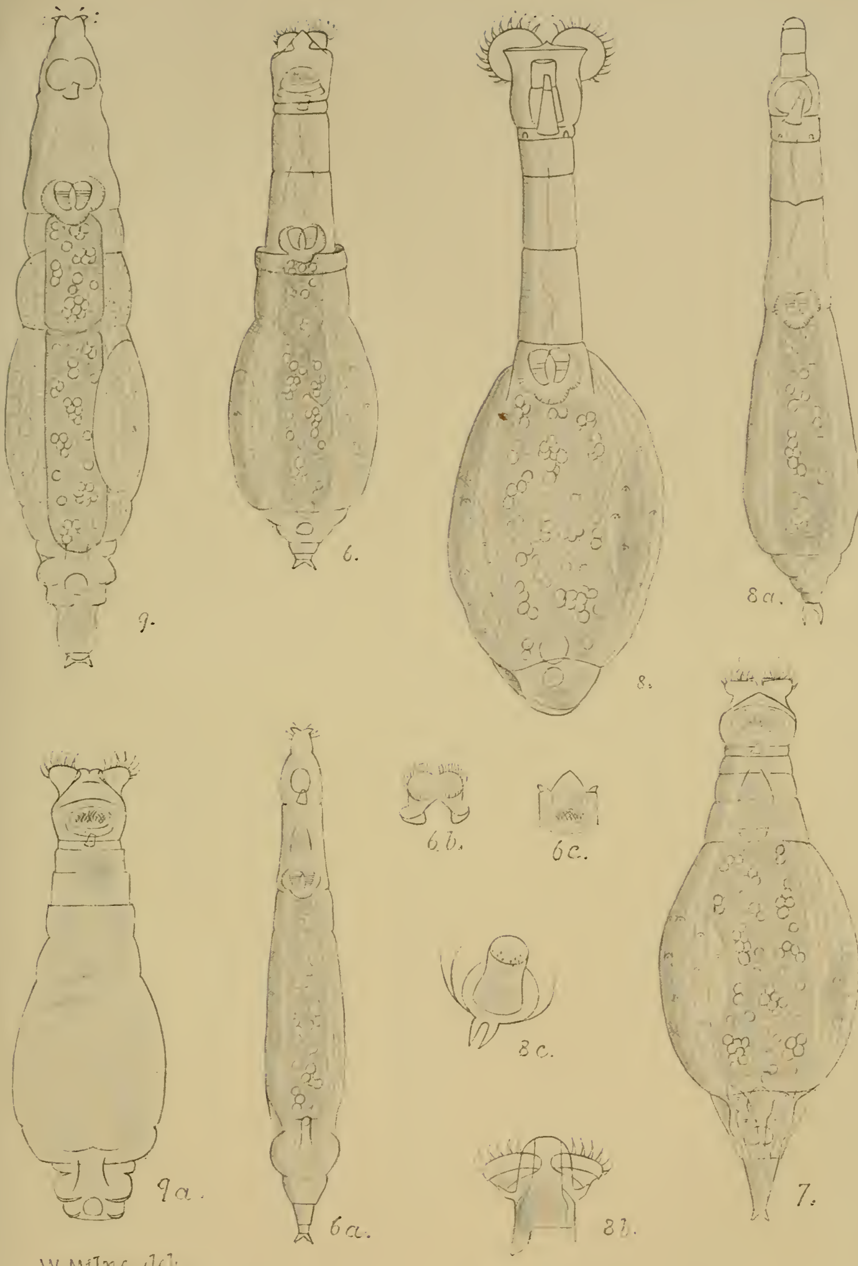

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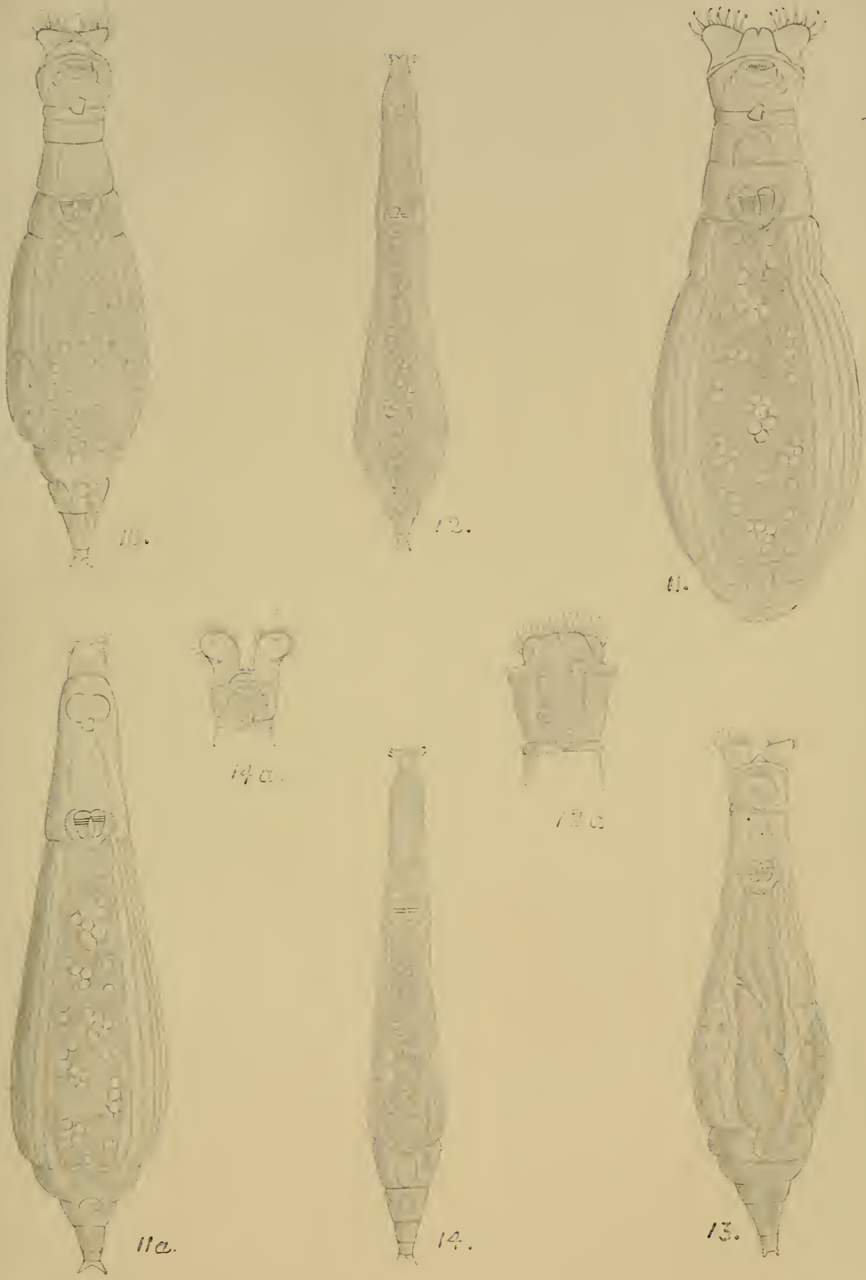
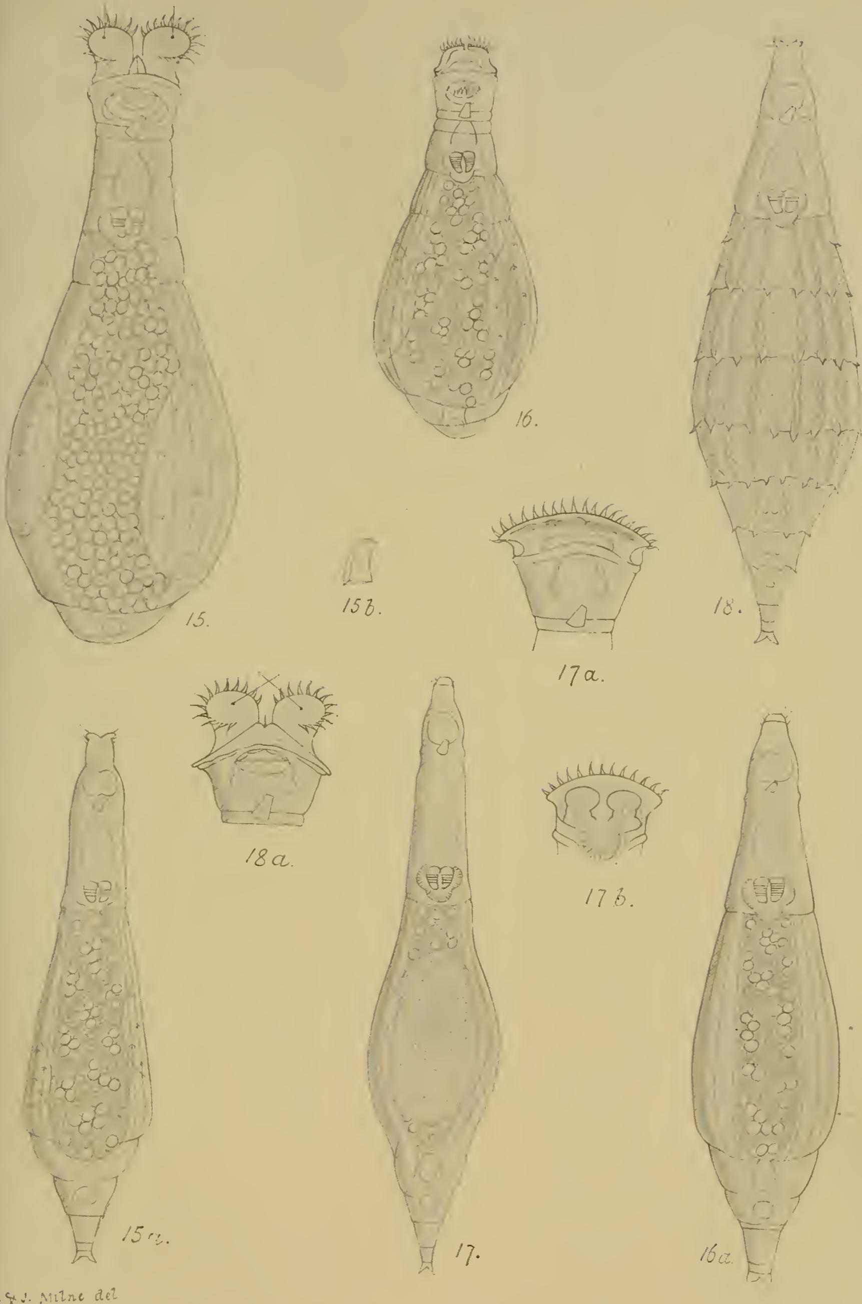
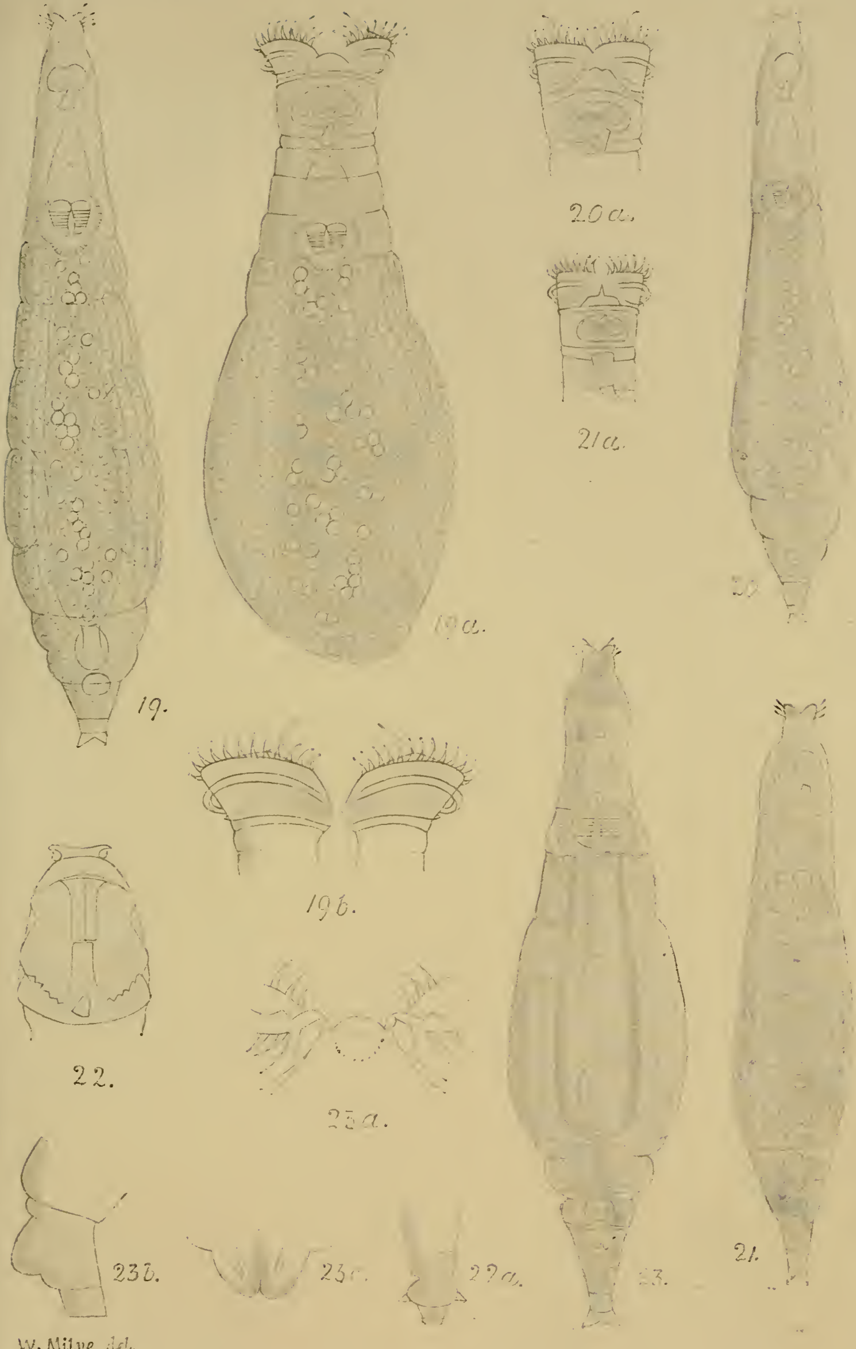


W. Milne del.

Bdelloid Rotifera of South Africa.



Bdelloid Rotifera of South Africa.



Bdelloid Rotifera of South Africa.

NOTICES OF BOOKS.

The Microscopy of Vegetable Foods, with Special Reference to the Detection of Adulteration and the Diagnosis of Mixtures. By Andrew L. Winton, Ph.D., with the collaboration of Dr. Josef Moeller and Kate B. Winton, Ph.D. xiv + 702 pages. $9\frac{1}{2} \times 6\frac{3}{4}$ inches. 635 text figures. (New York: John Wiley & Sons. [London: Chapman & Hall.] 1916. Price £1 7*s*. 6*d*. net.)

This valuable contribution to applied analytical science has for its purpose the identification of food products of vegetable origin, by the microscopic structure and microchemical reactions of their tissues and cell-contents. As the subject matter is essentially a department of applied botany, the study and practice of it cannot be properly taken up until after a course of instruction in vegetable histology or the microscopic anatomy of phanerogamic plants. The practical study of food microscopy should commence with a systematic study of the most important seeds, fruits, leaves, flowers, roots and barks used as foods, or food adulterants. This work should include: the macroscopic anatomy; the histology of transverse (less often longitudinal and tangential) sections; the histology as studied in surface preparations of the successive layers obtained by scraping or stripping, and the microscopic character of the powdered, pulped or macerated material. The surface preparations provide the details of cell-structure most useful in practical work, while the examination of the powdered material supplies the characters of isolated cell-elements which are important in diagnosis. Although the work of microscopic examination is distinctly botanical, in many cases a satisfactory idea of a material can only be obtained by combining the microscopic with a chemical analysis.

The preparation of materials for examination, the principal histological elements and the morphology of organs are all dealt with in the first part of the book. The following parts

are devoted to the special articles which are grouped together under such headings as Grain, Oil Seeds, Legumes, Nuts, Vegetables, Spices and so on. This grouping may have some practical utility, but it strikes one as unscientific and leads to the constant use of a fairly full index. Each special article is divided into: general and macroscopic details, histology, diagnosis and bibliography. The histology is illustrated by over 600 figures in the text giving the transverse section, surface view of the cell-elements and other minute details which may enable the analytical histologist to name the seeds, roots, barks or other vegetable products, from which the material under examination was prepared. Although several of the special articles deal with vegetable products rarely found on the English market, the major part of the book cannot fail to be of very great service to the microscopic analyst in this country. In addition to the special bibliographies already referred to, there is a general bibliography and a glossary of technical terms. The labour necessary for the production of such a book must have been very great indeed, and the result reflects great credit on the authors.

The Practical Principles of Plain Photomicrography. By George West. xiv + 146 pages, 8 plates, 5 text figures. 10 × 7½ inches. (George West. Price 4*s*. 6*d*. net.)

The author of this excellent book rightly insists that the beginner should commence with low powers and as he gains experience proceed step by step to the use of the higher powers. The book is not overloaded with detail, but well-chosen adaptations are fully described only when they are found suitable for the end in view. One chapter deals with the use of a landscape camera for taking photomicrographs. More important is the description of the method adopted by the author for dispensing with the camera altogether. Here the author places the source of light with the microscope in a light-proof chamber through a hole in the wall of which the tube of the instrument projects. The plate is placed on an easel in another chamber, the dark room, where the exposure is made and the plate developed. The photographic apparatus is of the simplest form, no camera or dark-slide being used. The practical microscopist could

not wish for a more accurate or easy method of obtaining reliable photomicrographs than those described by the author in Part VII, who declares that by this method he has obtained his best results. Certainly the plates 3–8 which reproduce some of the author's work demonstrate the beauty of the results. There is a table giving complete details regarding the taking of the negatives for these illustrations. There is also included a chapter on special methods of illumination, a list of photographic necessaries and a number of formulae for solutions, etc. Altogether the book may be cordially recommended to the practical worker with the microscope, and even the experienced worker in photomicrography may find very useful hints for his guidance.

Aids to Bacteriology. By C. G. Moor, M.A., and William Partridge. viii + 278 pages. $6\frac{5}{8} \times 4$ inches. Third edition. (Baillière, Tindall & Cox, London. 1916. Price, cloth, 3*s*. 6*d*. net; paper, 3*s*. net.)

This well-known *vade-mecum* of the bacteriologist has now reached its third edition and nearly all parts of the book have been revised and enlarged. The amount of information contained in the compass of this small book is quite extraordinary, covering as it does the whole range of bacteriology, using that term in its widest sense. After an introductory chapter dealing with the classification and biology of the bacteria, we have three chapters dealing respectively with bacteriological apparatus, the preparation and use of nutrient media and the microscopic examination of bacteria. All the principal pathogenic bacteria are dealt with in chapters V–XIII, and these are followed by chapters dealing with the blastomycetes (yeasts), hyphomycetes (moulds), and the principal pathogenic protozoa. The wide scope of the book is indicated by the inclusion of chapters dealing with the special bacteriology of water, milk and other foods, air, soil and sewage, and the bacterial diseases of plants. A full index is provided.

We may congratulate the authors on the success they have achieved in compiling this useful and comprehensive little book.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 515th Ordinary Meeting of the Club, held on March 28th, 1916, the Vice-President, D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on February 22nd were read and confirmed.

Messrs. Reginald H. S. Bevington, Henry Clarke Terry, Herbert H. Smith, Alfred Hardcastle, David Gillies, Reginald W. Thomas, Georges Rasquin and John Tennant, M.A., were balloted for and duly elected members of the Club.

It was announced that the son of the late Mr. Dunstall had very generously placed at the disposal of the Club his father's collection of slides of Diatoms, Insects and Botanical specimens, for the curator to select any objects not already in our Cabinet. The collection contains many useful additions, and the best thanks of the Club are due to Mr. Dunstall for the donation in memory of his father, who was such an enthusiastic member of our Club.

The following additions were made to the Library:

Ray Soc.: *British Marine Annelids*, vol. iii., part ii., plates, W. C. McIntosh; *Principles of Plant Teratology*, vol. i., W. C. Worsdell; *British Freshwater Rhizopoda and Heliozoa*, G. H. Wailes, vol. iii. Presented by Henry Morland: Index to the Localities named in Plates 1–288 of Schmidt's *Atlas der Diatomaceen-kunde.* Presented by Alpheus Smith: Q. M. C. Register; *Elements of Entomology*, W. S. Dallas.

Mr. W. Milne, M.A., B.Sc., F.R.S.E., gave a paper, "On the Bdelloid Rotifera of South Africa," Part I. Mr. Milne said the material for the paper had been gathered intermittently during the last ten years. A few of the species described were aquatic, but the large majority were moss-dwellers. The aquatic species

are probably very numerous in South Africa, but little attention had been paid to them. Only a few meagre lists of South African Bdelloida, with no description of new species, had been published when in 1911 Murray's *Bdelloid Rotifera of South Africa* was issued. In it he mentioned fifty-three species as having been found, forty of which he had himself seen. Of these forty Mr. Milne had seen all but seven, and of the other thirteen he had seen ten. He had been enabled to widen the scope of his investigations by the help of several friends, who provided moss from various localities, and some of the species were named after them. Mr. Milne had corresponded with Mr. Bryce, and had received assistance and helpful suggestions from him, and also from Mr. James Murray. Mr. Bryce had done a great service to students of Bdelloida in publishing his new classification. He had brought order out of what was fast becoming chaos and his classification was excellent.

Mr. Milne's paper (Part I) treats of one new family, two new genera, fourteen new species, and two new varieties of South African Rotifera. In addition to the systematic definition, details of structure, habitats, mode of life, feeding, method of swimming and crawling, and even their capacity for enduring captivity are fully described. It was impossible to give all this during one evening ; but Mr. Milne had prepared lantern slides from the drawings illustrating the paper, and with their assistance alluded to some of the most interesting points of a number of species.

The Chairman expressed great appreciation of the paper, with its description of such a large number of new species. He invited discussion, and himself inquired whether Mr. Milne had come across any males among the rotifers of South Africa.

Mr. David Bryce regretted the absence of Mr. Rousselet, who would have enjoyed the paper. He said all would look forward to the second part, containing the remainder of the species. He was pleased to see Mr. Milne proposed to make a new family for *Monoceros*, which was quite necessary. It was interesting to know this species had been found in England—he had found it in the river Lydd, and the late Mr. Dunstall had found it at Lynton. He was sure we should all be pleased to have the paper in the Journal.

Mr. Milne, in answer to the chairman, said he had not come

across any male rotifers in South Africa. He expressed his gratitude to Mr. Bryce for the assistance he had given, and his admiration for the system of classification he had originated. At the suggestion of the chairman, a very hearty vote of thanks was accorded by acclamation to Mr. Milne for his lecture. The chairman also proposed a vote of thanks to Mr. Biss, of the Photomicrographic Society, who had come at very short notice, and notwithstanding the terrible weather, to take charge of the lantern in the unavoidable absence of their own member who usually undertook that duty. This motion was heartily endorsed.

At the 516th Ordinary Meeting of the Club, held on April 25th, 1916, the President, Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on March 28th were read and confirmed.

Messrs. Emile Topsent, Arthur W. Aldis and Rev. W. Francis Deey, M.A., were balloted for and duly elected members of the Club.

The President said the members would be sorry to hear he had just received the news of the death of Mr. C. Lees Curties, which occurred on April 24th. He and his father before him had built up a unique business, and 244 High Holborn was regarded by many as a rendezvous where one was sure to meet some kindred spirit and to hear the latest scientific news. Mr. C. L. Curties greatly extended the business by the establishment of a factory where microscope stands are made, and of an optical department for the construction of object glasses. He had a thorough knowledge of the microscope, as well as a wide and varied acquaintance with all sorts of scientific instruments. He was always ready to place his expert knowledge at the disposal of anyone who asked his advice. There can be little doubt that his death was hastened by the heavy strain due to extra work on account of the war, and to his persistent refusal to give himself a much-needed holiday. Mr. Curties had been a most useful member, always willing to give assistance to the Club in every way, and his kindness and courtesy were known to all. He was elected a member in June 1880 and F.R.M.S. in 1894. A formal motion of regret and condolence with the relatives was passed.

The list of Donations to the Library included four books from the late Librarian, Mr. Alpheus Smith—for which the cordial thanks of the Club were returned.

Mr. Chapman Jones read a short paper on "The Secondaries or Dotted Structure in the Pinnulariae." This explained and described a series of photographs which he exhibited. He said that about forty-five years ago Mr. H. J. Slack contributed a note to the Royal Microscopical Society, in which he remarks that at one time it was supposed that the Pinnulariae were distinguished from allied forms by solid costae replacing beaded bands, but subsequently this distinction was not considered valid. That an examination of the Pinnulariae on Möller's type-slide led to the belief that instead of broad, irresolvable ribs, a truer view of the costae showed fine lines of beads springing from the median band, with a furrow between them, and in that furrow another line of beads at a lower level.

In a discussion which followed, Mr. O'Donohoe said he was glad Mr. Chapman Jones had brought the subject before them. When he had done so it was considered by a few members that the structure had no real existence, but Mr. Chapman Jones had quite confirmed his ideas on the matter.

There were seven photos exhibited, taken with a 2-mm. Holos objective, N.A. 1·36, × 8 compensating eyepiece, and a Holos immersion condenser. In some the effects of a solid central cone of light were shown, while others were taken with oblique light and a green screen. The magnification was from × 1,200 to × 1,300. In all of them the dots were visible and bore out the author's contention that they occurred on a membrane, which, under normal conditions, would form part of the structure of the diatom-valve as usually seen. The chairman expressed the gratitude of the meeting to the lecturer for his interesting exhibit and the paper explaining it.

The Hon. Secretary then read a paper by Mr. A. A. C. Eliot Merlin, F.R.M.S., on "*Nitzschia singalensis* as a Test Object for the Highest Powers." Mr. Merlin had received from Mr. E. M. Nelson a styrax mount of *N. singalensis* from Amherst in Burma. Its minute structure is similar to that of other varieties of the genus, but is extremely fine. The transverse striae had been seen by Mr. Nelson, but most other microscopists had failed to make them out. Mr. Merlin thought that

Amphipleura pellucida was no longer a sufficient test for objectives of the highest power: for many years any tolerable oil-immersion of moderate aperture could easily reveal its once elusive transverse striae by oblique light. Really good objectives of 1·3 N.A. will reveal them with axial illumination. Of course, to show the dotted structure is a more difficult task. "With *Nitzschia singalensis* the case is different, and any microscopist who can clearly reveal the transverse striation may feel satisfied with his optical appliances." A very beautiful photograph at 3,600 diameters taken with a 1/8th apochromat of 1·42 N.A., by means of oblique sunlight from a heliostat, accompanied the paper. This not only showed distinctly the transverse striae, but was a most artistic production, and was greatly admired when passed round for the inspection of the members.

In response to the President's request for a discussion on the subject, Mr. Ainslie said he quite agreed with Mr. Merlin that *A. pellucida* as a test leaves something to be desired, and that its resolution is no great feat at the present day. But as a result of his experience he thought that until we have Nitzschia mounted in realgar the resolution of the transverse striae of Amphipleura with a *full* solid axial cone of illumination remains the best test of the all-round capacities of an oil-immersion objective. He considered that there is no doubt that Mr. Merlin possessed unusually keen eye-sight, and thought that most microscopists need not be surprised nor disappointed if they fail to see the striae of Nitzschia except under the most favourable conditions of illumination and manipulation. Mr. Ainslie had a microscope on the table, with a Leitz 1/10th oil-immersion of 1·33 N.A., with which he was easily able to show the striae of Nitzschia. He said not only was this interesting in connection with Mr. Merlin's valuable paper, but also it served as an example of the occasional utility of a device for the enhancement of resolution by the introduction of an analysing Nicol prism into the path of the rays. He found that a very small illuminant was also an advantage.

The President said they were all much indebted to Mr. Ainslie for his remarks on the paper, and the thanks of the meeting were voted to the author.

The President invited Vice-President David Bryce to take

the chair, and proceeded to give a short address on the spicular structure of a sponge, *Geodia japonica*, of which he exhibited a dried specimen. His description was illustrated with sketches on the blackboard of the various forms of spicules, with a tabular list of their names. He said that on a former occasion he had brought before the meeting a very different example. He had then purposely chosen a very simple sponge—Dercitopsis; in the present case a much more advanced condition of the skeleton was found. The general structure of the skeleton in the genus Geodia is figured in Bowerbank's *Monograph of the British Spongiadae*. Typical specimens of *Geodia japonica* are cup-shaped; but they are often irregular in form, and in the specimen shown the cup-shape is not fully realised. It was not intended to give a description of the soft tissues, which it would be impossible to investigate satisfactorily in the dried specimen. There are the usual inhalent pores and exhalent oscula, but in this species these are covered over, and are not conspicuous. In Dercitopsis there is no striking differentiation into what used to be called skeleton and flesh spicules, now known as megascleres and microscleres; but in all the higher members of the Tetraxonid sponges the difference is very marked. The skeleton spicules are large, and of them the skeleton is built up, while the flesh spicules are small, often very minute, requiring high powers of the microscope to resolve them satisfactorily. It is a curious thing that they are usually scattered between the skeleton spicules, and seem to serve no important purpose in the economy of the sponge. The types of spicules do not differ much in the various species of Geodia. In *G. japonica*, amongst the megascleres we have first a form belonging to the triaene series, the orthotriaene; this has one ray very much elongated and three much shorter ones. The short rays lie more or less at right angles to the long ones; hence the name. The second type is the anatriaene, in which the three short rays curve backwards, making a grapnel form. The third type is very frequent, and is called the oxeote, and consists of a long shaft sharply pointed at each end; it is sometimes as much as 2 mm. long. The fourth kind of megasclere is a small oxeote. Amongst the microscleres the first type is known as the oxyaster; it is a star with a variable number of rays, often five or six. These are sharp-pointed and rather long: they are supposed

to be derived from the primitive tetract form by an increase in the number of rays. The second type of microsclere is a very small aster, with short, blunt rays, known as a pycnaster. The third type is the curious form called the Geodia ball, or sterraster. It is a curious spicule, consisting of an oval body, of larger size than either of the others, and practically solid. It has a depression on one side, supposed to mark the position of the nucleus of the mother cell. Prof. Sollas has figured the Geodia ball with a nucleus. It consists, like other siliceous spicules, of hydrated silica or opal. The surface is covered with small projections. If you take a section of a Geodia ball—an optical section can easily be focused—you find it is composed of enormous numbers of slender rods, radiating from the centre, and each one terminating in one of the surface projections. The development shows it to be a true aster. It starts as an ordinary aster; as it enlarges it becomes a form with slender hair-like rays, radiating from the centre; as they increase they thicken till they meet one another, and finally a further deposit of silica gives rise to the marks on the surface. The arrangement of the spicules is as follows: Taking the megascleres first, we find that if you look at a cut surface of the sponge, you notice towards the outside a definite radial arrangement; towards the inside this is confused. The radial arrangement is due to bundles of megascleres, which run towards the surface. The heads of the orthotriaenes are extended beneath the cortex, whilst the shafts run inwards for a long distance. Associated with these are found the anatriaenes. The larger oxeote spicules tend to form very loose bundles, but towards the interior they lose this arrangement. The whole sponge is covered with a white incrustation about 1/3rd mm. thick; this is composed entirely of the Geodia balls. Here we have a case where certain of the microscleres have a definite function, forming a protective armour on the outside. The minute pycnasters are on the extreme outer surface. The oxyasters are scattered throughout the ground substance, between the main spicules of the skeleton. It can be seen that there are canals ramifying through the body of the sponge, but the minute structure of the canal system cannot be determined from the dried specimen. This sponge belongs to the Astrotetraxonida, as shown by the astrose character of its microscleres.

The President had brought a number of carefully cut portions of the sponge for distribution amongst the members; the natural position and arrangement of the spicules could be studied by cutting sections of the specimen. For examination of the individual spicules boiling with a 10% solution of hydrochloric or nitric acid and washing are required, the spicules being finally mounted in Canada balsam.

Vice-President Bryce expressed the thanks of the meeting to the President for his valuable and interesting address, and for his kindness in providing the material, which would be studied by the members with much pleasure. His remarks were heartily endorsed by all present.

At the 517th Ordinary Meeting of the Club, held on May 23rd, 1916, the President, Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on April 25th were read and confirmed.

Messrs. Cyril F. Hill, F.R.M.S., John Rudd Leeson, M.D., Alfred George, Edmund A. Robins, and Alfred McEwen were balloted for and duly elected members of the Club.

Mr. J. E. Barnard delivered a lecture on "X-ray Research into Organic Structure as Exemplified by the Foraminifera." As an introduction to this and as an illustration of the capabilities of Mr. Barnard's method, Mr. E. Heron-Allen, F.L.S. etc., President of the Royal Microscopical Society, projected on the screen an interesting series of lantern slides of Foraminifera. He remarked that Mr. Barnard had obtained results which to him seemed most remarkable, and of the deepest significance.

Until Mr. Barnard had applied X-rays to the production of skiagrams of microscopic objects, the only method available for studying the internal structure of the opaque foraminiferal tests was by the laborious and often unsuccessful method of rubbing them down into thin sections on a hone, and after mounting them in Canada balsam examining them by transmitted light. This, though satisfactory in many cases, was hardly practicable where one specimen only was available, as the risk of accidental destruction, especially in the later stages of this process, was very great. Among the arenaceous forms, where the test is built up of sand grains more or less firmly

held together by a kind of cement, the difficulty of avoiding injury in an attempt at rubbing them down is very great, while not a few cases occur where, though the shell is calcareous, it has embedded in its substance particles of sand of varying size and hardness. These examples were dealt with by Mr. Barnard's process with a success which could be obtained by no other means, and numerous examples were thrown on the screen where the internal structure was admirably displayed, of course without any chance of disturbance having taken place, as the tests had not been interfered with mechanically in any way. In *Astrorhiza arenaria* the branching tubular body-cavity was perfectly shown in spite of the incrustation of sand on the exterior. *Cyclammina cancellata* gave a view of the labyrinthine wall-structure which could not otherwise have been obtained, quite free from any suspicion of alteration, and absolutely without injury to the original specimen. *Orbiculina adunca*, which is normally opaque, revealed its spirally wound coil of chambers in the most perfect manner, notwithstanding the difficulty of the varying thickness of the shell in different parts. Fossil forms even, such as Nummulites, were successfully dealt with, and a quite remarkable amount of structure was shown as still existing capable of demonstration.

Mr. J. E. Barnard said:

"Some previous work on the application of X-rays to the study of microscopic objects had been reported upon in the *Comptes Rendus*, but the methods adopted did not seem to promise very satisfactory results. As an outcome of the fine work of Laue, Friedrich and Knipping the molecular structure of crystals was exactly demonstrated, and it was shown also that X-rays were a form of light differing only in wave-length from the Herzian rays or those of other parts of the spectrum. This work was followed up by Bragg in this country and it constitutes one of the greatest advances in physical science that has been made in recent years. The important fact that X-rays could be reflected from a crystal surface was one of the results arising from these experiments.

"We are confronted with the fact that for the last thirty years, with one exception, there has been little actual advance in microscopic optics. We know, too, that theory and practice are almost in agreement: that the optician has been able to

produce lenses so nearly perfect that they almost reach the theoretical limit. The only method by which any substantial increase in numerical aperture, and consequent resolution, has been obtained is by the use of ultra-violet light. By this means resolution has been increased beyond the utmost that can be obtained in any other manner. When reading the records of the work done on X-rays, I was impressed with the idea that if we could in any way use these rays as a source of energy for microscopic work it would take us a great deal farther. Assuming that some means of utilising them to the full is found, it should be possible to demonstrate structure and to obtain resolution that is inconceivable by any method at present available. The slides Mr. Heron-Allen has kindly exhibited were the outcome of some experiments to determine how far one might be able to go in obtaining direct radiographs of microscopic objects, enlargements being obtained by photographic means. The method adopted for producing the radiographs is quite simple. The tube used is provided with a lithium glass window, so that the soft X-rays are freely transmitted. Ordinary glass obstructs these very seriously. The tube is enclosed in a lead-covered box, so that the rays cannot pass out except in the desired direction. There are two or more lead diaphragms fixed in a tube placed above the lithium glass window, each diaphragm having a small central hole. By this means an approximately parallel beam of X-rays of very small cross section is transmitted. The object is placed in the path of this beam, which passing through it impinges on a photographic plate placed in actual contact with the object. The resulting radiograph is of course the same size as the microscopic object (unmagnified), and the enlargement to lantern-slide dimensions, or whatever magnification may be desired, is obtained by ordinary photomicrography. One of the difficulties encountered was the necessity of obtaining plates with a sufficiently fine grain to record the extremely minute details and to allow of effective enlargement. But that this and other problems had been successfully overcome was apparent from the beautiful series of lantern photographs that had already been exhibited."

The lecture was followed by an interesting discussion in which the President and Messrs. Hilton, Ainslie and Blood took part, and by a hearty vote of thanks which showed the appreciation

by the members of a most interesting and valuable demonstration and lecture.

At the 518th Ordinary Meeting of the Club, held on June 27th, 1916, Vice-President D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on May 23rd were read and confirmed.

Messrs. Henry Wood and Ernest A. Maitland were balloted for and duly elected members of the Club.

The Chairman said he had a very painful announcement to make. Since the last meeting one of their oldest members, Mr. R. T. Lewis, F.R.M.S., died on June 10th, aged seventy-seven. He joined the Club in April 1866, within a year of its foundation. He was elected honorary reporter in the autumn of that year, and had most ably carried out the duties of the office ever since. His attendance was probably a record. At the 500th meeting he was able to say that he had been absent from his post on only eighteen meetings during the period, and almost all of these omissions had been caused recently by a severe illness. In the earlier days of the Club he frequently read papers, chiefly on entomological subjects. These may be found in the older volumes of the Journal, often beautifully illustrated by his skilful pencil. His presence was one of the most familiar to the members. He was at the meeting in April, but was unable to come to that in May, and passed away after about a month's illness.

They had also lost one of their honorary members. Mr. F. Enock died on May 26th, aged seventy-one. Mr. Enock was well known for his studies in entomology. Some years ago he had frequently attended their meetings and given occasional addresses on his favourite subject, but he had not been able to be with them in recent years. The members assented to the Chairman's motion that letters of sympathy and condolence be sent to the relatives.

The Hon. Secretary informed the meeting that he had received from Mrs. Priest, the widow of a former member, a cabinet of micro-slides for addition to the Club's collection. Mr. Priest was well known for his studies in sponges, and desired before his death that the Club should be presented with a num-

ber of his specimens. The Committee had accepted this very kind gift, and had directed that a letter of thanks be sent to Mrs. Priest. He thought that the members would like to endorse the action of their committee. This proposal was heartily assented to by those present.

Mr. W. Traviss exhibited and described an apparatus which he thought would be useful in pond collecting. It consisted of a hollow rod, about the length of an ordinary walking-stick, to one end of which was attached a triangular scraper. This also was hollow, and in communication with the interior of the rod. The top of the rod being closed by a finger, and the scraper being drawn over brickwork, wood, and similar objects under water, on removing the finger the water would rush into the tube carrying with it any organisms that had been removed by the scraper, they could be then transferred to the collecting-bottle. The action of the apparatus was similar to that of a dipping-tube on a large scale. The Chairman considered that the instrument would prove useful for the purpose for which it was intended, and proposed a vote of thanks to Mr. Traviss for bringing it before them, which was accorded.

The Chairman, introducing a paper by Mr. H. Wallis Kew, entitled "An Historical Account of the Pseudo-Scorpion Fauna of the British Isles," said Mr. Wallis Kew was a well-known authority on these creatures, which were unfortunately not much studied. The paper was a valuable one, and though there was not time to read it on this occasion it would appear in full in the Journal. Thanks were accorded to Mr. Wallis Kew for his communication.

Mr. A. E. Hilton then read a paper on "The Sporangial Characters of Mycetozoa and the Factors which influence them." He said: It is, perhaps, not sufficiently realised that in the small group of the Mycetozoa we have not only a convenient microcosm of elementary biological phenomena, but also a clue to the solution of some of the problems which these phenomena present. Applying to the Mycetozoa words used by an eminent physiologist in a similar connection, it may be said of these primitive organisms that they show with singular clearness how "quite simple combinations of well-known forces lead to the performance of complicated and apparently purposeful results." In the light of this luminous principle, which is true of all living

things, we may consider some of the sporangial characters of Mycetozoa.

"When we are asked what is the use of studying the Mycetozoa, our answer is, that, so far as we are able, it is our business, as microscopists and nature students, to make each small thing unfold its secret, and in so doing, perhaps, to unfold other and wider secrets."

The Chairman said: The formation of the sporangia of the Mycetozoa presented many important problems, and it had the advantage of lending itself to experimental work. No doubt surface tension plays a large part in the process, but it seems almost impossible to believe that such structures can be due mainly to that force. Of course the globular forms are the direct outcome of it, but the origin of the stalks, for instance, must require other factors. The whole subject is very interesting, and should repay much study and careful experiment.

Many of those present joined in a discussion on various points, and Mr. Hilton replied to some questions. Dr. Rudd Leeson recommended the study of several books as likely to throw light on the subject, especially one by Professor Bayliss, *The Principles of General Physiology*, and a very useful and inexpensive little work by Prof. B. Moore, *The Origin and Nature of Life*. At the suggestion of the Chairman a hearty vote of thanks was given to Mr. Hilton for his interesting paper.

OBITUARY NOTICES.

RICHARD THOMAS LEWIS, F.R.M.S.

March 21*st*, 1839—*June* 10*th*, 1916.

Richard Thomas Lewis was born at Knightsbridge in the parish of St. Margaret's, Westminster, on March 21st, 1839. He lived in the house where he was born until 1882 and was ever proud of being a Westminster citizen. There never was a truer Londoner. He often said he had rather have a garret in London than a mansion out of it. In middle life he served his parish as a Commissioner of the Duchess of Somerset's Charity and as a member of Committee of the first Free Library opened in London.

His education was begun by his uncle, Henry Lewis, who had a school at Colchester. At this time his school-chum was J. Archer Spurgeon, younger brother of the more famous Charles, who left the school soon after Richard Lewis entered it. Later, he went to a boarding-school in Stratford-le-Bow, where he learned from its inventor, Mr. John Freeman, the system of shorthand which he used with such success throughout life. Mr. Freeman aroused his interest in astronomy.

Early holidays were often spent with his maternal grandfather, Robert Mummery, at Dover. During these he learned to know and love the flora of the Downs.

In 1853–4 he studied at University College School, then under the direction of Prof. Key. On leaving school he entered business with his father, George Cyrus Lewis, but his leisure was filled with studies to which he turned eagerly, after days of what was to him mere drudgery.

He attended Tyndall's lectures on Light, Heat and Electricity, given at the School of Mines, and had some correspondence with the Professor on the apparent differences in the diameter of the moon. An experiment which he suggested was quoted by Tyndall in an article published in the *Philosophical Magazine* of May 1862.

In that year he was lecturing on scientific subjects to the parents of scholars at the Exeter Buildings Ragged School, off Sloane Street, and was giving similar lectures at the Sloane Street Y.M.C.A., in which he took a keen interest. He wrote the astronomical notes for the *Bible Class Magazine* for many years and supplied it with articles on various subjects, including an account of his first visit to Switzerland in 1868. His Swiss holidays were the only real relaxation he allowed himself, and after some thirty-five trips he was as keen as ever to see the beloved mountains again. His last journey was undertaken in 1914, when, after a considerably longer stay than he intended, he returned in a repatriation train and arrived home on the last Saturday of the fateful August. In 1866 he was elected a member of the Quekett Microscopical Club, and from the end of that year to April 1916 he acted as its Honorary Reporter. In July 1878 the Club presented him with a valuable gold watch which he always used. His chief papers are published in the Journals of the Club * and his chief interest in life centred round the friendships and scientific work which his membership brought him. About the same time he became a Fellow of the Royal Microscopical Society, whose proceedings he reported for over thirty years.

In addition to his more serious scientific work, which brought him correspondence from every continent, he was deeply interested in the scientific aspects of Temperance and gave many lectures on the principles involved. He constantly throughout

* The following is a list of the more important contributions Mr. Lewis made to the *Journ. Q.M.C.* 1. On the Male of *Icerya Purchasi* from Natal, vol. iv. p. 29 (1889); 2. On the Stridulating Organs of *Cystocaelia immaculata*, vol. iv. p. 243 (1890); 3. On a New Species of Aleurodes—*A. asparagi*, vol. vi. p. 88 (1895); 4. On a Stridulating Organ in a South African Ant—*Streblognanthus aethropicus*, vol. vi. p. 271 (1896); 5. Notes on some Australian Ticks received from Mr. C. J. Pound, vol. vii. p. 222 (1899); 6. A Contribution to the Life-history of *Ixodes reduvius* (Linné), vol. vii. p. 381 (1900); 7. On an Undescribed Species of Chelifer—*Chelifer sculpturatus*, vol. viii. p. 497 (1902); 8. Note on the Larva of Mantispa, vol. xi. p. 213 (1911); 9. Note on *Solpuga ferox*, vol. xi. p. 507 (1912); 10. The Early History of the Quekett Microscopical Club, vol. xii. p. 425 (1915). Mr. Lewis's papers were generally illustrated by beautiful drawings executed by his skilful pencil. [Editor.]

life wrote articles and gave lectures of a popular character, chiefly on subjects of a scientific nature.

In 1884 he removed to Ealing and soon joined the Ealing Microscopical and Natural History Society. He served on its Council and acted as a Vice-President.

For twenty-six years he was secretary of the Haven Green Baptist Church and only resigned when failing health compelled him to lead a less strenuous life.

He went to live at Blackheath in 1914, but continued to go to business, travelling daily to Paddington, up to within a month of his death. After four weeks of acute suffering, only partially relieved by an operation, he died on June 10th, 1916.

EMILY J. LEWIS.

FREDERIC ENOCK, F.L.S., F.R.M.S., F.E.S.

April 17*th*, 1845—*May* 26*th*, 1916.

IT is with great regret we record the death of Mr. Enock, which took place at Hastings at the age of seventy-one years. Mr. Enock was born at Manchester in 1845 and was educated at the Society of Friends' School, Ackworth, Yorks. He joined the Birmingham Natural History Society in 1865 and was for some time latterly the Father of the Society. He joined the Quekett Microscopical Club in 1871 and was elected an Honorary Member in 1912. Mr. Enock had become well known to many by his popular lectures on Insects, Spiders, etc., illustrated by coloured drawings of exceptional skill and beauty. He also contributed illustrated articles on Entomology to the popular magazines. His chief claim to scientific distinction is the work he did on the till then little-known group of the Myrmaridae, minute hymenopterous insects which pass their larval stage as egg-parasites. A monograph on this group of insects—"fairy-flies" as Mr. Enock styled them—had been in preparation for some years and we are informed was nearly ready for publication at the time of his death.

It is very probable that Mr. Enock was the first to mount insects for the microscope "without pressure." At the Loan Collection of Scientific Apparatus, held at South Kensington in 1876, he exhibited "A Collection of Entomological Prepara-

tions for the Microscope." The following explanatory note appeared in the catalogue of the Exhibition: "Some of these preparations are mounted in a deep cell and by being treated in a peculiar manner their natural form is preserved and the internal structure of muscles and tracheae seen in their natural positions."

NOTES ON THE COLLECTION OF BDELLOID AND OTHER ROTIFERA.

By David Bryce.

(*Read January 23rd,* 1917.)

Figures 1 and 2.

Since the first discovery of Rotifera by the illustrious Anton van Leeuwenhoek rather more than two hundred years ago, these most interesting microscopic organisms have captured the attention and the admiration of generations of microscopists, who have willingly devoted much labour and much midnight oil to the investigation of their structure, of their habits of life, of their relationships among themselves, and of their affinities with other groups of the animal kingdom. They have found in them a most remarkable diversity of form, allied with the most complicated and specialised organs, an astounding variety and activity of movement, an infinity of devices for the capture of their food, and in every direction an intelligence as surprising as it is undeniable.

So far as I have been able to ascertain, the first English naturalist who published any original observations with regard to the Rotifera was Henry Baker, whose name is so familiar to us all in connection with the well-known species *Brachionus Bakeri,* so named by the celebrated O. F. Müller in honour of our countryman. In his *Employment for the Microscope* (1753) Baker gave exceedingly quaint descriptions of the very few species known to him, and these attracted great attention among continental microscopists of the eighteenth century. After Baker's time there does not appear to have been any original work done by English observers in connection with Rotifera until the middle of the nineteenth century. The only works

which appeared in this country during the long interval were Pritchard's *Natural History of the Animalcules*, published in 1834, and the same author's *History of the Infusoria*, published in 1842. These books were little more than compilations, the latter especially being largely based upon Ehrenberg's *magnum opus* of 1838, and I take it that the first distinctively English work in this direction of the later school of microscopists provided with instruments of the modern type was the short paper published by Brightwell in 1848, and followed by papers in 1849 by Dalrymple and by Dobie, and in 1850 by Gosse. Since that time the lamp of the English enthusiast in the study of Rotifera has been kept continuously burning, largely owing to the encouragement afforded by the Royal Microscopical Society and by the Quekett Microscopical Club since its foundation in 1865. No very great progress, however, had been made, when Hudson and Gosse published in 1886 their epoch-making monograph, *The Rotifera or Wheel Animalcules*, which, together with the Supplement of 1889, brought into focus all that had been ascertained with regard to these highly organised animals, and provided workers at home and abroad with a new starting-point for further researches and wider investigations. Although the difficulties which had previously beset the English worker, who had laboriously endeavoured to identify his captures from the figures and descriptions given in the 4th Edition of Pritchard's *Infusoria* (the best book available in the early "eighties"), were not altogether dispersed by Hudson and Gosse's work, they were very considerably lessened and the fascinating study of the Rotifera received an impetus which can be measured not only by the tremendous volume of later literature, but also by the long and exceedingly useful lists of more recently described species so carefully compiled by Rousselet, and published from time to time in the *Journal of the Royal Microscopical Society*.

The species comprised in these lists total approximately *nearly one and a half times* as many as had been included in Hudson and Gosse's monograph, even after making liberal allowance for insufficiently described and for twice-described animals. This fact can only be considered as remarkable, when it is remembered that these authors had furnished particulars of practically all

the commoner and cosmopolitan forms and of a great many of the rarer species.

If, however, Rousselet's lists are examined from the standpoint of the habitat in which the various new species have been met with, it will be apparent that while undoubtedly much the greater proportion of these recent discoveries have resulted from collections in areas not previously searched, nevertheless quite a large number of the species have been found in habitats which are more or less outside the ordinary activities of the pond-life worker.

These notes on the collection of Rotifera will accordingly deal, not only with the customary methods of Pond work, but also with some less usual methods and with work which has little or nothing to do with ponds at all. The Rotifera which are to be obtained by the latter methods belong principally, but not exclusively, to the order of the Bdelloida, to which I have given my greater attention for many years past.

In speaking of Pond work, I use the phrase in its most comprehensive sense. I include in it not only the collection from pools and ditches of all sorts, sizes and positions, but also from running waters, and especially the smaller streams, rivulets or mere runnels, from lakes, reservoirs and canals; and even from rock-pools and brackish waters.

The methods of collection which I refer to as customary are the use of the net, the use of the dipping bottle, and the selection of portions of water-plants. These several methods are to some extent provided for in the ordinary pond collecting outfit, and it seems needless to describe them in detail; but some suggestions with regard to the net and its use may be worth consideration.

The most suitable form of net for the capture of Rotifera depends largely upon the character of the body of water in which it is to be employed, and upon the habits of the species which it is expected or hoped to capture. The habits of the Rotifera in their turn depend principally upon the nature and abundance of their special food. Those species whose food consists of smaller or weaker organisms, either swimming or floating, mostly swim themselves in search of their prey, and

they swim near the surface or deeper down according to the level or zone in which the food organisms are most plentiful. Another extensive series of species feed on the microscopic algae, which grow more or less thickly upon the stems and leaves of all kinds of water-plants, and, while readily swimming if disturbed, seem to spend most of their lives in carefully seeking their food where it grows, creeping all over the plants and nibbling here and there. Others, again, are fond of temporarily perching upon plants or confervoid threads, and feeding upon the organisms carried to them by the currents set up by the play of their own cilia. It is for the capture of rotifera of these various habits that the ordinary use of the net is most advantageous. In large ponds, where vegetation is frequently scanty, the net will mainly capture species which habitually swim. In small, shallow ponds with many and various water-plants, the second and third groups may be expected to predominate. Such weedy ponds frequently yield a much greater variety of species than the larger ponds, especially if the net be roughly worked among the vegetation to disturb those rotifers which may be creeping or resting upon the plants.

Judging from recent photographs of happy Quekett excursion parties, the net mostly employed in such pond work is a quite small, single net of about the shape of an ordinary funnel. I have rarely used a net of this small type, and cannot therefore speak positively as to the results obtainable by its use. But it seems to me to be only useful for the capture of such rotifers as swim quite near the surface, or for use in very shallow ponds.

Now it has been shown by Dieffenbach * that in ponds of moderate depth the swimming rotifers are throughout the daytime in greatest abundance at a depth of about half a metre (say 20 inches); whilst during the night their distribution in the water is practically uniform. It follows from this that the collector who confines his use of the net in such ponds to the surface of the water simply limits thereby the range of his captures. The general object in using a net is not to capture a crowd of

* H. Dieffenbach and R. Sachse, Biologische Untersuchungen an Rädertieren in Teichgewässern, *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, Leipzig. Biol. Suppl. 1912.

rotifers of a very few species, but rather to secure representatives of as many species as possible of those inhabiting the pond at the time of collection. I prefer therefore a larger net, which can be used not only for surface dipping, but also for deeper work, as well as in larger bodies of water, where rotifers are generally present in much fewer numbers. For this more general use, I think that the depth of the net should be not less than one and a half times the diameter across the mouth. When collecting at a depth of several feet below the surface, it is easy to turn such a net so that little water can enter it before it reaches the desired depth; it can then be opened fully, and again closed before withdrawal.

The diameter of the net has also some importance; a very small net-ring would be of little use in working large bodies of water, or for the plant-washing methods employed by Murray to which I shall presently refer. For general work I prefer a ring of not less than six inches diameter, as large, in fact, as will easily enter a side pocket, and an oval outline is perhaps more convenient than the round. In these days the net material is usually Swiss "bolting silk" of suitable gauge (No. 14 or 15), but Harring (who also, I think, prefers a large net) has used China silk, and I have found Indian silk fairly satisfactory.

To the single net generally employed I have the objection that it admits into the catch too many Entomostraca, larvae and other unwelcome guests. I cannot affirm that I have at any time seen Entomostraca attack rotifers, but I am certain that they consume quantities of food which would otherwise be available for the latter. If it is desired to keep the captured rotifers alive, the Entomostraca, larvae, water-worms, etc., are better left in their native pools. In recent years I have therefore made use of a double net of two different textures, the outer of the customary material, and the inner of muslin sufficiently close to act as a coarse filter to keep out, at least, the larger of the objectionable intruders, while permitting rotifers to pass through.

This double net had, however, the disadvantage that it was impossible to get at the "catch" unless the inner net was unattached to the net-ring on one side. I happened to mention

this difficulty to Mr. Harring, of Washington, and he most kindly sent me a special metal tube, to take the place at the foot of the net of the customary glass tube. The metal tube measures $3\frac{1}{4}$ inches in length, and $1\frac{1}{8}$ inch in diameter. At the lower end it is closed. At the upper end it is provided with an easily detachable and closely fitting rim, which is permanently attached to the outer net in the same way as the usual glass tube or bottle. The body and the rim of the metal tube are held together by two bayonet catches (one at either side), which can be readily disconnected, thus allowing the contents of the tube to be poured into another receptacle. The metal tube has the further advantage of avoiding the risk of breakage of the glass tube—always at the least opportune moment—when the net is used in ponds with a stony bottom. The whole arrangement is easy to work and is effective in permitting the contents of the tube to be secured without displacing or leaving unfastened the inner net.

I believe that a fitting has been devised whereby the "catch" is received into a short metal tube provided with a stop-cock, but as a part of the latter projects considerably beyond the surface of the tube, I imagine the arrangement to have disadvantages as compared with that now described.

But while the single or double net will secure a large proportion of the species of Rotifera living in a given pond, it will not secure all. Besides those species which swim, or which creep over or perch temporarily upon water-plants, there is the important and interesting group of rotifers which take up a permanent position on suitable plants, in many cases secreting or constructing for themselves a sheltering tube; and again another group, which seek their food among the detritus at the bottom of the pond. The former group are usually captured by bringing home portions of water-plants, and for this purpose a selection of suitable portions is generally made at the pond-side with the help of a pocket lens. There is perhaps no method of collecting rotifers which requires more judgment and experience. Great assistance is given by the use of a suitable receptacle for the plants that are thus being looked over. One of the most prominent members of our Club some thirty years ago used for

this purpose what became known after him as the "Hardy flat bottle," which can be easily made in the manner described later.

The aquatic plants most productive are those with finely divided leaves, such as the various water Ranunculi, Ceratophyllum, Myriophyllum, etc. The ubiquitous *Elodea canadensis* (better known perhaps as Anacharis) is also a favourite plant, and the humble Duckweed *Lemna minor* should not be despised, as it is much favoured by the plant-loving rotifers, and some of the very earliest discoveries of such forms were made from the examination of the pendant roots of this floating species. The ivy-leaved Duckweed, *Lemna trisulca*, I have not found to be so useful.

The portions of water-plants brought home can be kept alive in glass jars or aquaria for periods varying according to the plants themselves, some enduring under such conditions for months, others only a few days. It is desirable to have at the bottom of such receptacles a moderately thin layer of muddy sand to provide food for the small protozoa which in their turn form the principal food of many of the Rhizotan Rotifera.

Of those species which habitually feed on the broken-down vegetable substances at the bottom of the pond, ordinary pond work with the net will only capture stray individuals. By the use of the dipping bottle a better selection can frequently be secured, either by taking home a single bottleful, or by passing several bottlefuls through the net and taking the results home.

These bottom-feeding species are usually accompanied by several species of the Gastrotricha, which are mostly of the same habit. Dr. Voigt, a very successful collector of Gastrotricha, during two years spent at the Plön Biological Station, made use of the following more elaborate method:

A narrow-necked bottle of suitable capacity had its lower end fixed into a canister partly filled with lead. To the canister were attached two cords which were brought together in a ring above the neck of the bottle. The whole was knotted to a line and was then ready for use. The adjustment of the various cords was so arranged that when the bottle was dropped into the water at the desired spot, the mouth could be caused to lie close above the muddy bottom, when the gradual filling of the

bottle could be judged from the rising bubbles. Some fifteen to twenty such bottlefuls were thus collected and filtered at the pond-side through a No. 16 silk net, and the small remainder of water taken home. There it was first passed through a coarse filter and then through a No. 18 silk. The new remainder left upon the latter was next diluted with 1 to 2 c.c. of water and examined drop by drop under the microscope. When Gastrotricha were in greatest abundance, two or three individuals would be found in each drop. Dr. Voigt states that in the pond to which he refers the water thus collected from the bottom was very foul and smelt strongly of sulphuretted hydrogen.

I have not yet had an opportunity of trying this method, but it seems likely to produce better results than can be obtained with the dipping-bottle as commonly used, and although specially devised and useful for Gastrotricha, it would probably answer equally well for bottom-feeding Rotifera. It certainly has the advantage that it can be used at a greater distance from the bank.

In some ponds where there are floating masses of confervae, it is exceedingly useful to squeeze handfuls into the net, as many species, notably of the Rattulidae, habitually feed either upon the contents of the living cells or upon the semi-decayed and broken-down portions. A small quantity of such algae may be taken home to provide food for Rotifera in tanks or other receptacles.

In working rock-pools it is desirable to shake in the net handfuls of the more filamentous algae, but it must be remembered that marine algae are extremely fragile and that their decay is much more rapid than that of the fresh-water forms.

In searching for Rotifera in the Scottish Lochs, where vegetation is commonly very scanty, James Murray made use of a similar method to obtain these and other microscopic animals free from debris or larger intruders. In *The Rotifera of the Scottish Lochs* he thus describes his plan : " Water-plants of any kind, especially mosses and the finer-leaved flowering plants, are collected along the margin of the lake. They are placed inside a conical net of No. 6 Swiss bolting silk (an ordinary tow-net). This is put inside another net of very fine silk (say No. 17 to 20). The whole is then immersed in the loch with the rims

of the nets an inch or two above the surface. The water-weeds are then stirred and shaken about and washed in the net as in a bucket in order to detach the organisms which adhere to them. The plants are then thrown away and the coarse net lifted out of the fine one and allowed to drip into it. We then have in the fine net only microscopic organisms and fine sediment. It has been found by experience that even very large Rotifers will readily pass through the No. 6 net. Possibly giants like Stephanoceros would not pass through, but such animals are found by the direct examination of portions of water-plants under the microscope."

Where the broad leaves of water-lilies, or even the floating leaves of Potamogeton occur, it is worth while to gently scrape the under surfaces, placing the result in a separate receptacle for home examination. It is also worth while to occasionally examine the egg-masses of water-snails, when these are available either in freshly collected weed or on the sides of aquaria.

In ponds, ditches, canals, rivers, etc., there is sometimes a stone-faced bank or other stone- or woodwork in the water. When it is possible I make it a rule to put my hand below the surface to feel if there be a submerged growth of any kind upon the accessible portions. Sometimes one finds short-stemmed mosses, sometimes a thick furring of thread-like algae, sometimes only a slimy coating. Any of these are worth taking home for examination. One can either pick off a little with the finger and thumb or use a flat-sided tobacco tin to scrape off a square inch or two. Several species of the Bdelloida (for instance, the elusive *Philodina erythrophthalma*) are best got by this method, which for a long time I thought had not been employed by earlier workers. Recently, however, I read in Eichhorn's interesting book that he was accustomed to collect such material about a hundred and forty years ago.

In some places it is possible to scrape from the upper portions of partially submerged stone a dried encrustation of algae, which had been submerged when the water was at a higher level. Samples of such crusts should be taken, and treated as will be presently described for dry mosses.

One more method of pond work should be kept in mind. It

is the examination of such animals as Asellus and Gammarus, Nepa, Caddisworms and all kinds of larvae and water-worms, and of various algae for those species of Rotifera which infest them either as a source of food, as a means of transport or merely as a shelter. It would occupy too much time and space to enter into particulars of the various grades of parasitism shown by such Rotifera. It suffices to say that some, indeed most of them, are of the most interesting nature, and that here, as in other matters, "it is the unexpected that happens." As an instance of the "unexpected," I may mention the discovery about fifteen years ago, by a young Italian student, in the course of his studies for the Degree of Doctor, of three unknown species of parasitic Rotifera in the gill-cavities and actually upon the gills of the Freshwater Crab. Two of the species belonged to the Bdelloida, and the third was a member of the genus Distyla, a genus usually associated with weedy ponds and sphagnum bogs.

I think it is more than possible that if one of our younger men would take up the study of parasitic Rotifera, as a special line of investigation and in a systematic fashion, he would make some very interesting and valuable discoveries. In the case of Asellus and Gammarus, nearly every individual carries with it several parasitic Rotifera, and the former animal is the usual host for at least half a dozen different species. If an Asellus or Gammarus be confined in a live box so that it cannot move freely, the Rotifera will presently leave their positions. It is then easy to remove the Asellus and to isolate the rotifers for closer examination. Another method is to place several Aselli or Gammari in a small, wide-mouthed bottle half filled with water. The bottle is then well shaken, and the rotifers forcibly detached from their hold. By pouring off the water into a stage trough, the rotifers, being carried with it, can be easily picked out under the microscope and isolated. Asellus is usually found among water-plants in weedy pools—Gammarus more frequently in muddy ponds. In running water, however, the latter can sometimes be found by lifting stones from the bottom. Both of these hosts should be collected from as many different localities as possible, and the results carefully noted for comparison one with another. The rotifers which are parasitic upon

these two animals, and especially the Bdelloid species, are exceedingly difficult to keep alive after removal from their host. Being apparently merely "lodgers," they do not in any way feed upon their hosts, but I have no doubt that they derive some direct benefit from the water-currents set up by the branchial movements of the latter. When deprived of these currents, and confined in a small cell, they rarely feed and soon perish.

I come now to the work which I have referred to as outside the ordinary activities of the pond worker, viz. the collection and examination of moss.

The occurrence of certain Bdelloid Rotifera in moss had been noted by Ehrenberg many years ago, in the *Transactions of the Berlin Academy*, but only in scattered papers, all, I think, subsequent to the publication of his great work *Die Infusionsthierchen* in 1838, and these few and unemphasised references seem to have escaped attention either in Germany or elsewhere. The rediscovery by Milne and by Zelinka independently, about 1886, that moss is a favourite home or shelter for such Rotifera, has led to its being more systematically collected for examination, and thus to the discovery of very numerous species which had otherwise in all probability remained unknown.

Since 1886, the work of searching for moss-dwelling Rotifera has been carried on steadily by several workers, and notably by James Murray, whose untimely loss in the ill-fated Steffansson Expedition is still fresh in our minds. Murray's magnificent use of the opportunities afforded him by the Lake Survey Trust, by the Shackleton Expedition to the Antarctic, and by the Bolivian Boundary Commission has enriched our knowledge of the Rotifera by over a hundred species, gathered in all quarters of the world, and of these the greater number had been met with in more or less direct connection with moss.

The work which has already been done by the various moss enthusiasts has made a very notable alteration in our conception of the Rotifera in general, and of the Bdelloid Rotifera in particular. Before 1886 the Bdelloida were looked upon as being, like the majority of other Rotifera, inhabitants principally of pools and ditches. It has now become well established, that

only a minority of the Bdelloida pass their lives in such habitats, and that the greater number of the species of this group habitually live in all sorts of situations, under all kinds of conditions, away from pools and ditches, and are quite able to sustain life and to thrive, if occasionally supplied with water by the fall of rain, or even by the evening fall of dew. The knowledge of such potentialities, not in one or two animals, but in a long and constantly increasing array of species, must considerably affect our estimate of the importance of Rotifera in the animal kingdom.

Under the heading of Moss work I include the collection of Fontinalis or similar mosses found occasionally in masses in running waters in hilly districts, and of those finer-leaved forms sometimes found in ponds; of mosses growing on submerged stones or wood; of all bog-mosses, and especially Sphagnum, whether in bog-pools or elsewhere; of all mosses from dripping rocks or wet banks; of all tree-mosses and mosses on tree-stumps; of roof-mosses, wall-mosses and ground-mosses, and even, and by no means least, of pavement-mosses. To put it more briefly and comprehensively: of mosses from anywhere and from everywhere. I also include the collection of liverworts and even lichens, although the latter have only occasionally been found to harbour Rotifera. For the present purpose it will be convenient to divide these various mosses (and liverworts) into two categories: the wet mosses, including all those which are found growing in positions usually wet; and the dry mosses, comprising those which grow in positions usually dry—that is, in dry weather. As the wet mosses are in some respects the easier to deal with, I refer to them first.

Such mosses as Fontinalis are generally found growing in some quantity and are frequently very productive. Some handfuls should be washed in the net and the results placed in a separate bottle, as they must be looked over as soon as possible, the water being so overburdened with impurities that it will not remain sweet for long. I also take home a moderate supply of the wet moss in a metal box, first allowing the water to drain off, and then packing the moss very loosely. If thus treated and kept in a cool place, even these coarse yet tender mosses

will remain in good condition for some weeks, and thus provide material for later examinations. If desired, some of the wet moss can be placed in a glass jar with water, and this will live well for some time. When an opportunity arrives for the examination of the moss stored in the metal box, a portion should be placed in a wide-mouthed bottle of 4 to 8 oz. capacity, and the bottle half filled with water. To dislodge any animals attached to it, the moss is then stirred vigorously about with the butt of a penholder or other suitable weapon, and afterwards removed. After allowing the water in the bottle to settle, a portion is poured into a stage trough and searched under a low power for swimming species. The trough should be large enough to permit of the introduction and free use of a fine pipette. If no swimming species are present, or those seen are not wanted, I pour away the greater part of the water from the bottle, and after shaking up the remainder, refill the trough. The latter is placed in a sloping position, so that the sediment may settle on one side. When the water has fairly cleared, the trough is transferred to the stage of the microscope (which, it is understood, is inclined at a convenient angle), that side of the trough on which the sediment has fallen being kept underneath. Any Rotifera present will mostly be found moving among the sediment, and individuals desired for closer examination can be picked out with the pipette. If the sediment lie thickly, it is sometimes desirable, after some minutes in the inclined position, to stand the trough upright, when most of the sediment will fall to the bottom, leaving many of the rotifers attached to the glass side. With a little care it is not difficult with the tip of the pipette to push the rotifer from its hold without injury, and to draw it into the pipette before it can regain its position. The operation requires a little practice, as it must be done while the trough is on the stage of the microscope. The trough is held firmly with the left hand, and the pipette managed with the right. For all preliminary work in searching through pond gatherings or moss washings I use a 1-inch objective with an A or No. 1 eye-piece. The further treatment of the selected specimens will be described later.

When the contents of the trough have been sufficiently searched,

and all the desired specimens picked out, the trough can be emptied and refilled from the stock bottle and so on. If further examination of the stock is to be deferred to another occasion, I pour away gently the greater part of the remaining water, and replace with clean water before placing the stock aside.

I have not myself met with Fontinalis in the London district, only in really hilly country. In some of the Epping Forest ponds I have occasionally found masses of finer-leaved mosses, which I have treated in the same way.

A more easily obtainable moss is Sphagnum, which lingers on in greatly reduced quantity in some parts of Epping Forest, whilst on the moors of the north and west country it is generally abundant wherever there is boggy ground. Although several of the Rotifera which frequent this moss are also found in mosses growing in dry situations, there are a few species, such as *Habrotrocha angusticollis*, *H. lata*, *Scepanotrocha rubra*, *Stephanops stylatus*, *S. tenellus* and *Distyla agilis*, which are very rarely found elsewhere. Besides these there are at least two species that habitually live in those remarkably large cells which form the cortical layer of the stems of the side-branches of Sphagnum. Each of these cells is provided by nature with an external opening, which admits the water within the cell-cavity. In the dim ages of the past, *Habrotrocha Roeperi* and *Habrotrocha reclusa* have discovered the possibilities of such cells for the purpose of shelter, and they have, in fact, become tenants at will of these single-roomed, self-contained residences, taking possession by simply squeezing through the doorway—the natural orifice of the cell. Once inside, the rotifer finds itself in sufficiently roomy quarters, where it can turn about, and if all goes well, lay its eggs, and, so to speak, bring up its family, living at peace and paying no rent. When it is hungry it pushes its head and neck through the orifice and commences to feed. To find these animals *in situ* it is necessary to strip the leaves off the side-branch. It is not known definitely whether they inhabit all kinds of Sphagnum. I have seen some forms in which the cortical cells had openings which seemed too small to permit the entrance of the rotifer.

The general treatment of Sphagnum differs somewhat from

that necessary for the Fontinalis group of mosses. Sphagnum should not be washed roughly in the net, it is too fragile for that method. It is better to simply squeeze handfuls into the net, and it is also useful in suitable places to turn up one's sleeve and plunge a bottle deep down among the long roots and there fill it with the water and to empty it into the net a few times. Sphagnum frequently harbours several species of Ploïma, and especially members of the family of Cathypnidae, even when it is not growing in or alongside a pool. The swimming species are most plentiful in Sphagnum growing in bog pools, and are mostly species which rarely or never occur in the ordinary pools and ditches. The rotifer worker should make a point of searching Sphagnum wherever he finds it growing. The results of moss squeezing should be examined as soon as possible, as the swimming species are mostly delicate forms which do not live well in confinement. Sphagnum should also be brought home, and if lightly packed in a metal box will keep in good condition for some weeks. It should not be squeezed before packing, and it must not be allowed to get dry. I think it best to wash it in very small quantities when making a stock, and treating it comparatively gently. I have also had good results from packing it fairly tightly in a bottle, adding sufficient water to thoroughly soak it. When I desired to examine it, I shook the bottle and then poured some of the water into the stage trough. But with this method there is some risk of the Sphagnum fermenting, with fatal consequences to all Rotifera. Wet mosses from dripping rocks or wet banks should be dealt with in the same way as the dry mosses to which I next refer. They should be stored in metal boxes or in bottles, and not allowed to become dry.

Mosses which grow in positions usually dry should not be gathered during rain or even shortly after being wetted by rain or dew. They can be kept either in metal boxes or in paper bags. The grease-proof paper now so generally employed makes a good wrapping for small packets.

The possibility of getting living rotifers from dry material is a consequence, fortunate for the microscopist, of the wonderful capacity of certain Rotifera of retaining their life in spite of

being apparently absolutely dry. In some books of reference I have seen statements which implied that all Rotifera could submit to desiccation and still survive. The real fact is that this remarkable property is practically confined to the Bdelloid Rotifera. In all the numerous samples of dry material which I have examined, I have been able to find and to revive only four different species which did not belong to the order of the Bdelloida, and even in this order the property is by no means universal. As is well known, the reproduction of Bdelloid rotifers takes place in two distinct fashions: in some genera the various species produce living young; in the other genera the various species produce eggs, whose segmentation does not commence until after their extrusion by the parent. It is found as a general rule that viviparous species do not live in situations where they are liable to be frequently dried up. Such places are almost exclusively inhabited by species which are oviparous. There is thus presumption of a direct connection between the habitat and the method of reproduction. In dry mosses one expects therefore to find only oviparous species, and very few exceptions to this rule are known.

The process of preparing themselves for their recurrent passive condition can be shortly described. By some means or another the animals are sensitive to the approach of the danger point of the evaporation of the water in which they are living. When thus warned they become restless, and finally utilise the telescopic capacities of their structure to withdraw the head and neck, and the foot, within the skin of the central body. From the skin now remaining exposed is exuded a liberal covering of some secretion, which hardens into an airproof coating as the animal is gradually left dry by the vanishing water. To be effective, the operation of exuding the secretion seems to demand a certain amount of time. If the animal be allowed to dry up quickly, it invariably fails to revive again if kept more than a very few minutes before being remoistened. On a glass slip that is free from sand or fragments of detritus, the drying takes place too rapidly. If, however, there is present a little sand around which the water clings, the rotifers have a better chance of assuming their air-

proof investment. Under natural conditions there is of course plenty of sand or vegetable fibres.

Once safely covered with his "airproof," the rotifer can endure months of desiccation, and in some cases they have been revived after several years. But the longer the period of desiccation, the smaller will be the proportion of the individuals that revive. In other words, the best results are obtainable from dry mosses when they are freshly gathered or, at least, not more than three or four months old.

When "wet" mosses are washed, the rotifers are active at once when the moss is placed in water; they have, in fact, never ceased their active life. They may have contracted themselves and may be lying motionless, but that is because they have been disturbed, and are temporarily frightened or simply timid and cautious. When "dry" moss is washed, some time must be allowed for the water to dissolve the protective coating, and to stimulate the dormant life to a renewal of activity. The time varies according to the period which has elapsed since the moss was collected. In the case of mosses recently gathered, it may be as short as ten minutes; in that of mosses which have been in hand for many months, it may be several hours before the animals begin to show signs of returning animation. Whatever be the period, part of it can be usefully employed in "clearing" the water of the "stock."

Mosses from wet banks and all dry mosses should be gathered with as little earthy matter about their roots as can be managed without dislodging animals adherent to the stems and leaves. With short-stemmed mosses some thickness of earthy material is unavoidable. Before washing such material, I generally shave or scrape off the moss-fibres just above the surface of the soil, to avoid putting the latter in the water. Even then a considerable proportion of dirt particles in the stock must always be expected in washing dry mosses. Most of it is usually sand, which will settle quickly when the stock is stirred or shaken up, and is not harmful. But there is always a proportion of very finely divided particles which remain suspended in the water after the sand has settled. These finer particles doubtless include great numbers of bacteria and much decaying organic matter.

If these fine particles are not removed from the water, the stock goes quickly sour and every rotifer present is poisoned. It is therefore essential that the water should be cleared; and this process, and the time which elapses before the rotifers regain activity, constitute the main differences in the treatment after collection of dry mosses as compared with that of wet mosses, such as Fontinalis or Sphagnum.

The moss is placed in a wide-mouthed bottle which is then filled nearly full with water. The capacity of the bottle may range from two ounces upwards according to the quantity of moss to be dealt with and its condition as regards adherent dirt. Clean mosses such as are gathered in woods and from tree trunks can be washed in larger quantities than short-stemmed mosses from the ground or from walls. As a rule, the moss should not more than cover the bottom of the bottle. When it has become thoroughly soaked, the moss is well stirred about and removed. The water in the bottle is allowed to settle for two minutes, in which time all sand and all rotifers will fall to the bottom, leaving the water more or less cloudy or even opaque. Some two-thirds is to be carefully poured away, and the bottle refilled. The procedure is repeated until, on refilling, the water is not perceptibly cloudy. After another two minutes the greater part is poured away, leaving only a remainder to be searched through as already described. A stock prepared in this way will generally keep in good order for some weeks, giving time to make a very thorough examination of the material, if it is found to be productive. A simpler plan is to place some moss in a bottle with a little water, and after allowing time for the rotifers to revive, to shake the bottle and then pour off the water into the stage trough. This plan answers quite well up to a point with fairly clean moss, but according to my experience the stock does not keep nearly so well as that which has been systematically cleared.

The sandy sediment which collects in roof-gutters, whether in town or country, nearly always harbours some species of Bdelloid Rotifera, and these can be secured by treating the sediment in the same way as dry mosses. In town samples the stock is usually very foul, and the water has to be changed many

times before the stock is fit for examination. I have also on some occasions obtained Bdelloida by washing dead leaves, and even from tufts of the common Thrift. I have no doubt that in wet weather and in places where disturbance of the surface soil is infrequent, Bdelloid Rotifera, and especially young individuals, creep about more freely over the ground than has yet been suspected. Moss therefore, although the most convenient for the purpose of the student, is not to be regarded as the only habitat of those Bdelloid Rotifera which live away from pools and ditches. In this connection I may mention some very curious habitats which have been brought to my notice. Some years ago Mr. Paulson handed me some specimens of a Lichen, *Parmelia revoluta concentrica*, which has the abnormal habit of growing concentrically all round some suitable loose core and thus producing an egg-shaped or spherical ball which is blown hither and thither by the wind on the open downs. In examining some examples collected on the South Downs, Mr. Paulson had discovered some Bdelloid Rotifera sheltering within the inner recesses. These rotifers proved to belong to the species *Macrotrachela nana*, a form usually met with in ground-mosses. At a later date I received from Mr. Harring a tube of soft fragments of rotten wood in which rotifers had been found by one of his friends. On first examination I was unable to find anything alive except some eel-worms, but I kept the material moist, and some six months later a second examination revealed numerous examples of the same species, *Macrotrachela nana*, which had been found in Mr. Paulson's specimens of Lichen. These two instances give ample proof of the potential adaptivity of the moss-dwelling Bdelloida.

Again, it will be remembered that Mr. Scourfield made recently some investigations as to the inhabitants of certain small collections of water among the exposed roots of trees, and that in the small receptacles formed by the natural twistings, etc., of the main roots he discovered a water-flea previously unknown. He also found numerous Bdelloid Rotifera, which I was able to identify as the rare *Habrotrocha bidens* (Gosse), and this species occurred dominantly in two different gatherings.

I come now to the after-treatment of the rotifers selected by

means of the pipette from the various gatherings or washings examined in the stage trough. When picking up the rotifer it is desirable to take with it as little water as possible. This can be attained to some extent (1) by the use of a very fine pipette of the form shown in fig. 1, e ; (2) by not filling the stage trough more than 1 inch deep. Having captured the rotifer wanted, I gently blow out the contents of the pipette upon a specially prepared cell-slide (fig. 1, d), depositing the water near the centre of the cell. It is essential that when the cover-glass is placed in position, the film of water should not much exceed $\frac{1}{2}$ inch in diameter, and that it should not at any point reach the cell-wall, the effect of these conditions being not only to provide in the cell a supply of air, but also to very considerably retard evaporation of the fluid contents. In most cases the water taken up by the pipette and deposited in the cell exceeds the desired modicum, and some must be withdrawn. The use of blotting paper for this purpose I find to be slow and risky. The first step is to remove with a forceps to another cell any coarse sand or large fragments of plant or moss. This done, I generally draw up the surplus water into the pipette by capillary attraction only, ensuring that the inflow is very slow by keeping my finger lightly pressed on the upper orifice. The water removed is deposited in another cell, in case, by misadventure, the rotifer may have been caught up as well. If the captured animal is a Bdelloid, it has probably contracted itself when first picked out, and it is well to wait a few minutes before removing the surplus fluid, to give it time to re-extend and regain its foothold. But even with all possible care, the animal will sometimes get stranded in the pipette. Therefore, when the capture is of more than ordinary importance, I adopt a slower but safer method. Placing the cell-slide flat upon my table, I take another similar slide, and lower it in a horizontal position, face downwards, over the first until it rather more than touches the drop of water. It is then carefully raised and brings with it a small portion of the fluid, and this is examined under the microscope to make sure that the rotifer has not been picked up. The procedure is repeated until the water is sufficiently reduced. If the rotifer be a "free-swimmer," it may be desirable to restrict

its movements, and this can be effected either by placing in the water a very few fibres of ordinary cotton wool or a few threads of Spirogyra or similar Algae. When the cover-glass is placed in position the water-film should be intersected by a thin network of fibres and broken up into numerous small enclosures within one of which should be imprisoned the rotifer. When the captive is a Bdelloid, this procedure is unnecessary. For ordinary observation Bdelloida must never be held in any degree, or they will not display the corona. In the cells which I use they have plenty of room. The water having been sufficiently reduced, the cover-glass is put on carefully and the slide placed on the stage of the microscope to make sure that the water-film does not reach the cell-wall. If it does, the cover-glass must be taken off and put on again until all is right. In such cases it is often advantageous to turn the cover-glass partly round before replacing it. When successfully carried through, the operation, which takes so many words to detail, occupies very little time. I have described the procedure as if dealing with a single rotifer, but in practice I generally pick out several examples and place all in one cell before removing the surplus water. I have had as many as seven different Bdelloid species living happily together for weeks in the same cell, having been introduced one by one in the way described.

With my cells I use 1-inch square cover-glasses, that size being much more easy to manage when the cover has to be temporarily taken off.

Many Bdelloida are much scared when transferred to a cell, and either remain obstinately contracted or march about restlessly and vigorously. As many species cannot be identified with certainty unless seen when feeding quietly and well placed, I find it best to leave such animals undisturbed in the cell for examination on another evening.

I have not attempted to keep any Rhizotan species in these small cells, and I find that very few of the free-swimming Ploïma will survive in such restricted quarters for more than a few hours. When examination of these animals is finished, it is best to restore them to the original gathering. Such exceptionally hardy forms as *Diaschiza gracilis*, *Metopidia lepadella*,

Monostyla cornuta and *Distyla inermis* will live for a few days if some fragments of plants, etc., are left in the cell to provide some food for them. Nearly all the moss-frequenting Bdelloida will live for at least a month under the same conditions, but the larger pond-dwelling species of the genus Rotifer seldom live more than a few days. Hitherto I have not supplied the captives with food to supplement that present in the cell, merely replacing when necessary the water lost by evaporation. I am now experimenting upon the results attainable by the supply at intervals of small quantities of microscopic algae of the nanno-plankton type, but so far with indifferent success.

The method I have indicated of placing the droplet of water (containing the rotifer) near the centre of the cell, and on no account permitting the fluid to extend to the cell-wall, is so far effective in retarding evaporation that even during summer temperatures the cells can be left in any cool place from one day to another without danger to the contents. For longer periods it is desirable to store the cells in a "damp chamber." That which I use (fig. 2) consists of three parts: an ordinary bell glass of about 7½ inches diameter and 8 inches high, a shallow basin of about 8 inches diameter at the bottom and a staging of galvanised wire (fig. 2, d), on which there is room for some thirty glass slips laid horizontally. The bottom of the dish is filled with water and old moss. In this chamber I have repeatedly kept cells undisturbed for more than three weeks, without their contents being dried up or the captive rotifers killed.

The advantages offered to the student of Rotifera by the use of these cells, etc., for winter work scarcely need to be pointed out. At a season of the year when it is difficult to screw up one's courage to a long tramp to a distant and desolate pond, one can have resort to the mosses stored up from more pleasant summer excursions and from them obtain animals which will interest and repay repeated examination.

I conclude these notes with figures of various pieces of apparatus which I find useful, and particulars of their construction in so far as they are of home manufacture.

The Hardy flat bottle (fig. 1, a, b) is in the form of an elongated

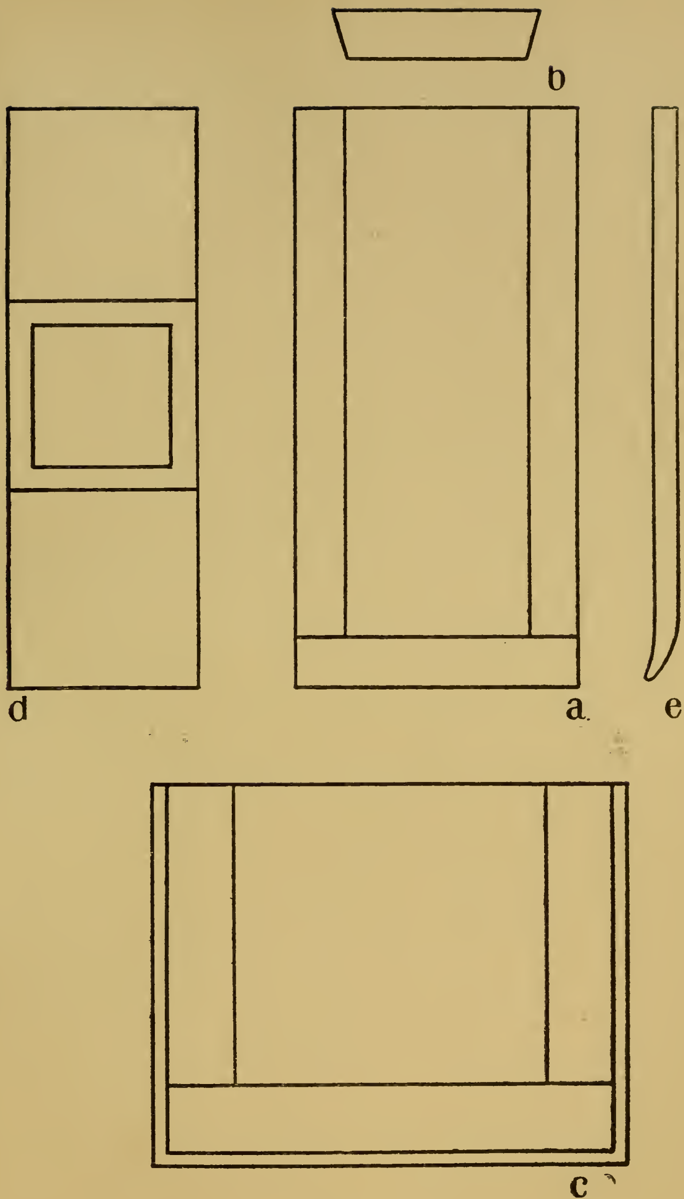


FIG. 1.

a, b, *One-half actual size.* c, d, e, *Actual size.*

trough. For the framework take an oblong piece of sheet-rubber $5\frac{1}{2}$ inches $\times$ $1\frac{1}{2}$ inch, and $\frac{1}{2}$ inch thick. Cut this lengthwise into three slips $\frac{1}{2}$ inch wide. Two of these will form the sides, and the 3-inch bottom is cut from the third, leaving a length of $2\frac{1}{2}$ inches to be cut again for a loosely fitting "cork" (fig. 1, b). For back and front provide two pieces of thin plate glass 6 inches $\times$ 3. To one of these cement the bottom slip of rubber and the two slips for the sides, making good joints between. After they are set hard, fix the other glass in position. I find in practice that troughs built up of three pieces of rubber cemented together last quite as well as those wherein the rubber frame is of one piece, as originally specified for this "bottle." The various dimensions and the thickness of the rubber can be varied, but those stated make a convenient and useful size. When cutting rubber the knife should be kept wet.

The stage troughs (fig. 1, c) are made in a similar way, but from rubber $\frac{1}{4}$ inch thick. The front and back are of thinnest plate glass $2 \times 2\frac{1}{2}$ inches. The rubber is cut into strips about $\frac{3}{8}$ inch wide and into lengths of $2\frac{3}{8}$ inches for the bottom, and $1\frac{1}{2}$ inches for the sides. These are cemented into position on one glass, and when hard set the other glass is fixed on. These measurements leave a small margin of glass at sides and bottom, and the glass should be so affixed that the trough will stand upright. For cementing I use ordinary gold size, sometimes mixing with it some powdered colour to harden it.

My ordinary "cells" (fig. 1, d) have the cell-wall made from thin lead-foil such as is used for capsules; for very shallow cells I use tin-foil. I cut this material into 1-inch squares and cut out the inner square of $\frac{3}{4}$ inch, leaving a square frame $\frac{1}{8}$ inch wide, which is cemented to the centre of a thin glass slip (3×1). Care must be taken to press out superfluous cement so that only the smallest effective modicum is left, and the cell-wall must be perfectly smooth and not thicker at one side than the other. Otherwise, when in use, capillary attraction will draw the cell contents to the thinner side. The same result follows if the lead-foil itself is too thick, but that can be remedied by planing the surface carefully with the edge of another glass slip.

The fine pipettes (fig. 1, e) are made from glass tubing of small

diameter. "Small $\frac{1}{8}$ inch" is particularly good. It is procurable at the chemical shop, and costs 3*d.* per length of 3 to 4 feet. The upper end of the pipette, on which the finger tip is to be pressed, must first be seen to. It must be cut clean, so that when the finger is firmly pressed on it no air can pass. A slight inequality can be reduced by holding the end in the flame of a

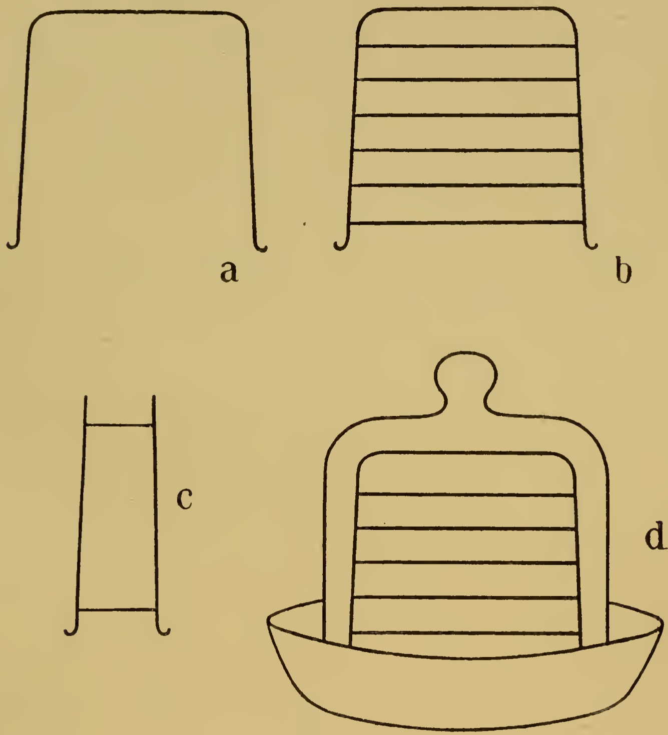


Fig. 2.

About one-fifth actual size.

gas jet and bringing it just to the melting point. If too rough or jagged, a fresh end must be made. Glass tubing is cut by nicking it with a three-sided file and breaking across. When the end is satisfactory, the piece of tubing is held in the gas flame about 3 inches from the end, and heated until it begins to bend. As it bends, the two extremities are pulled steadily

apart until the tube is divided, each piece having a tapering point bent over to one side. A small terminal opening (say about $\frac{1}{24}$ inch diameter) at right angles to the tip of the pipette is now made by careful grinding on a stone or the face of a file. It is useful to finish off the pipette by marking it near the upper end with a ring of red sealing-wax or bright-coloured cement, to make it conspicuous and easily found. A pipette used for any special purpose, such as dealing with narcotised specimens, should have a special mark, and be kept apart.

I find a pipette of 3 inches length the most convenient for use with the stage-troughs described. The larger pipettes with rubber teats or covers take up too much fluid and are more difficult to control, although admirable for dealing with larger quantities.

The staging (fig. 2, a, b, c), which forms an important part of the damp chamber (fig. 2, d), is made from galvanised wire, with the help of pliers. Two pieces of stout wire are each bent to the form shown in lateral view fig. 2, a. With rather finer wire passing from one upright to the other a series of shelves is made as shown in fig. 2, b. Finally the two pieces are bound together at each end as in fig. 2, c (end view).

The bottom of the dish being filled with old moss (kept very wet), the feet of the staging are pushed into the soft layer, which gives a sufficiently safe foundation.

THE PRESIDENT'S ADDRESS.

THE CHESSMAN SPICULE OF THE GENUS LATRUNCULIA; A STUDY IN THE ORIGIN OF SPECIFIC CHARACTERS.

By Arthur Dendy, D.Sc., F.R.S.
Professor of Zoology in the University of London.

(*Delivered February 27th,* 1917.)

Plates 15–17.

It is very well known that there are certain types of tetraxonid microscleres in which the spicule consists of an elongated, rod-like axis with whorls of outgrowths arranged at intervals along it. As a result of the study of some novel varieties of this type met with amongst the sponges of the "Sealark" collection, it occurred to me that the position of these whorls might correspond with that of the nodes in a vibrating rod, and that thus the form of the spicule might be determined largely by a well-known physical cause, the deposition of silica taking place chiefly where the rod was in a state of rest. The stream of water constantly flowing through the canal-system of the sponge seems to afford a sufficient explanation of such vibration, for the developing spicules are imbedded in the very soft, gelatinous mesogloea in the immediate neighbourhood of the canals. I submitted the problem to my mathematical colleague, Professor J. W. Nicholson, of King's College, and he was good enough to make some calculations which entirely support this theory. I do not propose to trouble you on this occasion with a detailed account of our results from the physical point of view, as we hope to publish a joint paper on the subject very shortly. In searching for further evidence, however, I was led to make a somewhat elaborate study of the so-called chessman spicule in two species of the genus Latrunculia, and the development of

these spicules proved to be so extraordinarily interesting that I thought it might afford a suitable subject for my address to you this evening.*

A good deal has been written on the development of sponge-spicules, and some of the published accounts appear to be very contradictory. It would seem from the observations which I am about to lay before you that this development is by no means so simple an affair as is often supposed, but is in reality a very complex process, the course of which is determined partly by physical and partly by what may be termed biological factors.

The two species of Latrunculia in question, *L. bocagei* and *L. apicalis*, were both obtained by the Challenger Expedition at Kerguelen, and the latter also off the mouth of the Rio de la Plata, and were described by Mr. Ridley and myself in the Report on the Challenger Monaxonida, published thirty years ago. Only the adult form of the curious chessman spicule was, however, described, and I had no idea, until I came to re-examine them the other day, that my preparations—consisting chiefly of a large number of sections stained with borax carmine and cut by the ordinary paraffin method—contained an almost perfect series of developmental stages.

Much as I deprecate the unnecessary introduction of new technical terms, I must venture to suggest that in future these spicules should be called "discorhabds" instead of "discasters." The latter term, first used, I believe, in the Challenger Report, was based upon a complete misconception as to the nature of the spicule, which does not belong to the astrose series at all, but is clearly shown by its development to be a linear type modified by the addition of disk-like outgrowths or whorls of spines.

The fully grown discorhabd of *Latrunculia bocagei* (fig. 7) is about 0·07 mm. in length—or height—and really bears considerable resemblance to a chessman. It consists of a straight, stout

* A brief account of the gross features of the development of the chessman spicule in *Latrunculia lendenfeldi* has been given by Hentschel (Monaxone Kieselschwämme und Hornschwämme der deutschen Sudpolar-Expedition, 1901–3). The course of events in that species evidently agrees in general with what occurs in *L. bocagei* and *L. apicalis*.

shaft, expanded at the lower end to form a knob-like base—which I propose to call the manubrium—ornamented with two circles of short spines. For some distance above the manubrium the shaft is free from outgrowths, but a little beyond the middle of the spicule there comes a whorl of three flattened lobes with denticulate or crenate margins, followed after a short interval by a similar whorl, and then, after another short interval, by a third whorl which differs from the other two in not being subdivided into three lobes. Following immediately on the third whorl is the broad, hemispherical apex, provided with a number of short, capitate spines and forming a sort of crown.

As we shall have to refer to them frequently and individually in what follows, it is necessary to distinguish the three whorls by special names, and for reasons connected with their development I propose to call them, in the order in which I have just described them, the median, the subsidiary and the apical whorls respectively (fig. 7, *m.w.*, *s.w.* and *a.w.*).

In *Latrunculia apicalis* (figs. 20–24) there is a very interesting specific difference in the form of the discorhabd, for, beyond the apical whorl, the spicule, instead of terminating in a crown of capitate spines, is produced into a very long, slender, tapering process resembling the "leader" of a growing fir-tree, to which, indeed, the spicule bears a striking resemblance. We may call this the apical prolongation (*a.p.*). Near the base of this process there is a single or double circlet of small spines, which may perhaps be regarded as a second subsidiary whorl (*s.w.* 2). Another difference, which is of considerable interest in connection with the vibratory theory, lies in the fact that the median whorl is a little farther from the apical whorl than in *L. bocagei*, being approximately midway between the apical whorl and the manubrium. The length of the fully grown spicule is about 0·126 mm.*

Of course individual variations in the form of the discorhabd

* Kirkpatrick, in his Report on the Tetraxonida of the National Antarctic Expedition, has described two supposed varieties of *L. apicalis*, in one of which two forms of discorhabd occur, one with and the other without an apical prolongation. I doubt whether either variety should be assigned to *L. apicalis*.

occur. The subsidiary whorl is occasionally developed between the median whorl and the manubrium, instead of between the median and apical whorls, but I have only seen this in the young spicule (fig. 17); or the subsidiary whorl may be missing altogether (fig. 21). A curious abnormality is represented in fig. 22, where a branch is given off from near the base of the apical prolongation and the chief subsidiary whorl is defective on the same side of the spicule.

It is obvious that the form of these spicules is remarkably well adapted to the purpose for which they are employed by the sponge, that purpose being the protection of the external surface. Here they are arranged in a dense forest, with their bases or manubria firmly implanted in the fibrous outer layer of the cortex, and their apices projecting freely. Placed close together, shoulder to shoulder, they form an admirable defence against the attacks of parasites or other enemies.

In view of their final disposition at the surface of the sponge, and the remarkable manner in which their shape conforms to the requirements of that situation, with base and apex each apparently differentiated for its special function, it is not a little surprising to find that these curious organs of defence originate and go through the whole of their development in the interior of the body, beneath the cortex and far removed from the position which they are destined and adapted to occupy. Anybody who cared to speculate about the purpose and intelligence exhibited by sponges would find here abundant material for cogitation. We can imagine him saying "See how the sponge first of all shapes these spicules into appropriate weapons, and then carefully arranges them in their thousands, all in the position of maximum efficiency; surely this implies something more than mere mechanical necessity, some purposive action such as we ourselves are capable of performing." It is perhaps quite as remarkable a case as any of those which have recently been brought forward by Mr. Heron-Allen from amongst the Foraminifera. It is, moreover, by no means unique amongst sponges, for we see the same phenomenon in the case of the cortical layer of sterrasters in the genus Geodia, and other instances are also familiar to the student of this group. The most

exact parallel that I know of, however, occurs in quite a different group of animals—the Hoplonemertines. These remarkable worms possess a long, eversible proboscis, armed at its tip with a single calcareous stylet, shaped like a nail. The head of the nail is fixed in a kind of handle, formed as a secretion by certain glandular cells. But the stylet does not develop in this position ; a supply of them is formed—apparently by the secretive activity of special mother-cells—and kept in reserve in little sacs which lie at the side, not far from the handle, and it seems that when one stylet is broken or worn out it can be replaced by another taken from one of these armouries.

But even if we assumed, which I am far from doing, that the removal of the discorhabds from their places of origin and their arrangement at the surface was due to some intelligent and purposive action on the part of the sponge, we should hardly be any nearer to an explanation, for the sponge is apparently devoid of any organs through which its intelligence might operate in bringing about such a result. The mystery will be cleared up only when we are in possession of adequate information as to the various changes through which the sponge passes in its development as a whole. We cannot solve such problems by the contemplation of completed results, and the truth of this statement is very well illustrated by the development of the discorhabds themselves, to the consideration of which we must now pass on.

It is generally believed that the siliceous sponge-spicule, whether microsclere or megasclere, originates within a mother-cell or scleroblast. In some cases it is supposed that the entire growth takes place within such a cell, but where very large spicules are formed it is suggested that the later additions of hydrated silica, or opal, are contributed by accessory silicoblasts. It has also long been recognised that the secretion of silica takes place around an axial thread of different but unknown composition, the position of which is frequently indicated by the presence of a more or less distinct axial canal in the fully developed spicule. The mode of origin of the axial thread, or "protorhabd" as I now propose to term it, is entirely unknown, but it seems generally to be assumed that it arises in the same

mother-cell which secretes the silica. About the actual existence of these two constituents of the spicule—the protorhabd and its coating of silica—there can be no doubt, but their mode of origin is a much more difficult question, upon which I hope that the following observations may throw some light.

It is extremely rarely, if ever, that the protorhabd has been detected as an independent structure, before the commencement of secondary thickening by the deposition of silica. In both our species of Latrunculia, however, we find something at any rate very closely approaching to this earliest stage, though it is difficult to be certain that there is still no siliceous deposit at all. Scattered sparsely through the choanosome, beneath the cortex, occur a number of very slender rods (figs. 1 and 8) about 0·04 mm. in length, which, unlike the silica which is subsequently deposited around them, stain rather deeply with borax-carmine. It is difficult to determine the exact shape of their extremities, but in *L. apicalis* one end appears to be more sharply pointed than the other, though this may not be a constant character.

I have not been able to demonstrate that these protorhabds arise within single mother-cells, though it is quite possible that it may be so. In any case I do not think that they can be looked upon merely as secretions, for in *L. apicalis*, as I shall show presently, they retain the power of independent growth long after the commencement of silica-deposition around them. I am inclined rather to compare them with the plastids found in many vegetable cells, in connection with which various substances, such as chlorophyll and starch, are deposited by the protoplasm. Such plastids are living bodies, capable of growth and multiplication, but they always seem to remain within their parent cells. The histological conditions in the sponge are, however, very different from what they are in plants, and it seems almost certain that the protorhabds sometimes grow far beyond the limits of any parent cell that there may be. It is the protorhabd which, as we shall see later on, is responsible for growth in length of the spicule; and when we remember that some spicules, such as those of the "glass-rope" in Hyalonema, or the even more remarkable fixing spicule in Monorrhaphis, may be considerably over a foot in length, it is evident that this struc-

ture must at any rate continue its activities independently of any possible mother-cell, whatever may have been its origin.

The material at my disposal for the purposes of this inquiry is naturally not well adapted to cytological investigation. Nevertheless it has been possible to make some observations in this direction. In *Latrunculia bocagei* I have repeatedly found certain small cells associated with the protorhabds, or with the immediately subsequent stages of development, in a very definite manner. In the youngest stage observed (fig. 1) there is already a distinct indication of such cells forming a ring around the protorhabd not far from the middle of its length. In the specimens represented in figs. 2 and 3 two such rings of cells are clearly visible, one a little above the middle of the spicule and the other about half-way between this and the apical extremity. It seems safe to conclude, from what happens afterwards, that there are normally three cells in each of these rings. I propose to term them the formative cells, for it is evident that they have much to do with determining the manner in which the silica is deposited. What their origin may be I am quite unable to decide, but there seem to be two possibilities. Either they are products of the division of an original mother-cell belonging to the protorhabd, or they are of extraneous origin and have become associated with the developing spicule secondarily. It seems probable that they continue to divide into daughter-cells as development goes on, and fig. 7 shows faint indications of what may be numerous minute formative cells arranged as a sort of veil around the mature, or nearly mature, spicule.

A single much larger cell of a very different type is also commonly found associated with the developing spicule, both in *Latrunculia bocagei*, where it may be present together with the formative cells, and in *L. apicalis*, where the formative cells have not been observed, though there can be little doubt that they are also really present. This cell is clearly shown in figs. 4, 7, 14, 15 and 18 (*a.s.*). It generally has the form of an oval, coarsely granular body with a definite outline. One of the granules may be a good deal larger than the others, and perhaps represents a small nucleus. On the other hand, the entire body itself looks like a very large nucleus, the cytoplasm belonging to which cannot

be differentiated from the surrounding mesogloea. In the specimen shown in fig. 7, however, the appearances are somewhat different, the body being irregular, with a fairly distinct nucleus in the middle, and seem to support the view that it is an entire cell with which we are dealing.

The nature of this cell is somewhat problematical. Others similar to it are found in the adjacent mesogloea, and I have by no means always found one in immediate association with the developing spicule. I venture to interpret it, provisionally at any rate, in the light of my recently published observations on the secretion of silica in the genus Collosclerophora,* of which I gave an account to the Club last year. It will be remembered that in that genus small masses of gelatinous silica are secreted by certain scleroblasts (silicoblasts) not unlike the cells in question. These masses of silica shrink up on dehydration and can be made to swell out again by the addition of water. They do not assume the definite form characteristic of ordinary spicules, but are rounded, sausage-shaped or kidney-shaped bodies enclosed in thin-walled vesicles formed either as precipitation membranes or by condensation of the surrounding mesogloea. I would suggest that the normal function of such cells is to bring up supplies of silica to the developing spicules, where it is utilised by the formative cells in building up the spicule around the protorhabd, and that in Collosclerophora the protorhabd and formative cells have disappeared, leaving the secondary or accessory silicoblasts, as they may conveniently be termed, to discharge their silica into the surrounding mesogloea in the form of collosleres. This hypothesis accords very well with what is known of the disappearance of entire spicule-categories in the phylogeny of many tetraxonid sponges, a subject to which I referred at some length in my last Presidential Address.

It would seem then, if these views are correct, that three factors may be concerned in the growth of a siliceous sponge-spicule: (1) the protorhabd, which is responsible for growth in length and serves as a foundation upon which silica is deposited; (2) the formative cells, which are responsible for the

* *Proc. Royal Soc.*, B, vol. 89, p. 315, 1916.

arrangement of the silica, and (3) the accessory silicoblasts, which supply the formative cells with the necessary material.

I may remark in passing that this hypothesis may help us to reconcile the apparently conflicting observations of certain authors who have dealt with this subject. Thus my friend Dr. Woodland, in the last of his "Studies in Spicule Formation," * contradicts the statements of Maas as to the development of the anisochela in Esperella. Maas says that four nuclei occur in connection with each spicule. Woodland says that there is only one. They are dealing with distinct species, it is true, but it is unlikely that there is any specific difference in this respect, and it seems at least possible that Woodland has seen only the large accessory silicoblast while Maas has seen the formative cells. Similarly I am now inclined to interpret the single, large, so-called "nucleus" figured by myself in connection with the anisochela of *Cladorhiza inversa*,† as an accessory silicoblast rather than as the nucleus of a mother-cell.

An analogy to the supposed behaviour of the accessory silicoblasts is perhaps to be found in the activities of the "nurse-cells" which I described in my memoir on the "Gametogenesis of *Grantia compressa*." ‡ These cells collect food-material, in the form of other cells, and convey it to the growing ova, just as the accessory silicoblasts are supposed to collect silica and convey it to the formative cells. The silica must, of course, be obtained ultimately from the water flowing through the canal-system, but how this is effected is entirely unknown. It seems probable that an accessory silicoblast is only temporarily associated with a developing spicule, and that, after parting with its load of silica, it moves off again to some favourable locality where it can collect a fresh supply.

After this somewhat lengthy and speculative digression we may continue our account of the development of the discorhabds. In the stage represented in fig. 2 (*Latrunculia bocagei*) the deposition of silica upon the protorhabd has already commenced, and thickening has taken place especially at two points, viz. at

* *Quarterly Journal of Microscopical Science*, N.S., vol. 52.

† Report on the Challenger Monaxonida, Plate XXI. fig. 13.

‡ *Quarterly Journal of Microscopical Science*, N.S., vol. 60.

one end (the future apex), where a distinct knob has made its appearance, and at a point a little above the middle, surrounded by the lower ring of formative cells. At the next stage (fig. 3) the apical knob has grown larger, and a third thickening has appeared in the middle of the upper ring of formative cells. A little later a knob, the commencement of the manubrium, also appears at the other end of the spicule, while each of the two thickenings corresponding to the two rings of formative cells is seen to consist of three conical projections arranged in a whorl, and the entire shaft of the spicule between the knobs and whorls has also become thickened, though to a less extent (fig. 6). I have not been able to detect any formative cells in relation with the terminal knobs, though I think it quite probable that such may be present.

The coincidence of the positions of the median and subsidiary whorls with those of the rings of formative cells suggests very strongly that the latter are directly concerned in their development, and the conviction that this is the case becomes irresistible when we study the appearances represented in figs. 4 and 5. Already in the earlier stages (figs. 2 and 3) it had become evident that the formative cells constitute a kind of sheath, partially, if not completely, enveloping the spicule. Around and between the median and subsidiary thickenings this sheath is separated from the spicule by a considerable interval. Presently it bulges out around each of the two thickenings to form three pockets (figs. 4 and 5) which no doubt correspond in position to the three formative cells. It also becomes distended to a less extent between the thickenings and above and below them, and this distention seems to take place only on one side of the shaft, though this lop-sided appearance may possibly be due to post-mortem changes.

I believe that the distention of the sheath is due to the accumulation within it of a very watery solution of silica—or possibly some silicate. In fig. 4 an accessory silicoblast is seen lying between the two rings of formative cells, and it is suggestive that it occurs on the same side as that on which the pockets are beginning to form. In the walls of these pockets traces of the formative cells can still be detected. I imagine that they

are taking up silica in solution from the accessory silicoblast and passing it into the space between the sheath and the spicule. The walls of the three pockets presently become highly refringent (fig. 5), suggesting that solid silica is deposited in them at some distance from the shaft, to form knobs which become connected with the shaft later on. These views are strongly confirmed by the examination of corresponding stages in *Latrunculia apicalis* (figs. 14, 15), although, as already stated, the formative cells themselves have not yet been observed in this species.

The development of the spicule up to this point is not, however, exactly similar in the two species, but shows certain well-marked differences which are of great interest from the point of view of the vibratory theory. In accordance with this theory the maximum deposition of silica takes place at the nodes or points of rest of the vibrating rod. In *Latrunculia apicalis* three thickenings usually appear simultaneously, one at each end and one approximately in the middle (figs. 10–14). The two end ones may appear before the middle one (fig. 9), though this seems to be very rare, but I have never seen the middle one present without the two end ones, and the two end ones are usually of approximately equal size. In *L. bocagei*, on the other hand, one of the terminal thickenings (the apical one) and the median thickening both appear before the basal thickening (manubrium) is recognisable at all (figs. 2 and 3), and it is a highly significant fact that the median thickening is shifted quite distinctly towards the apex—that is, towards the weighted end of the rod—which Professor Nicholson tells me is exactly what would happen if this thickening represented a nodal point.

In both species the subsidiary thickening now appears, usually between the median and apical thickenings, but occasionally, in *L. apicalis* at any rate, between the median thickening and the manubrium (fig. 17). Now if these subsidiary thickenings also represent nodes there should be two of them, one on each side of the median thickening, and we have to account for the fact that there is only one. The solution of this difficulty becomes obvious when we consider the arrangement of the formative cells in *L. bocagei*. There should be altogether

three nodes between the two ends of the rod, but there are only two rings of formative cells, and apparently the nodal thickening cannot take place in the absence of such a ring.

This brings us to another extremely interesting consideration. It must be primarily the position of the rings of formative cells that is determined by the vibrations of the rod, and only secondarily that of the local accumulations of silica which develop into the whorls of the adult spicule. It would seem that we have here a kind of tropism exhibited by the formative cells. Many different kinds of such tropism, or taxis, are already recognised, such as chemiotaxis, where the position of the cell results from response to chemical stimulation; galvanotaxis, resulting from response to electrical stimulation; geotropism, resulting from response to the stimulus of gravity, and so on. It seems only reasonable, on the evidence before us, to suppose that the formative cells are sensitive to vibrations in such a way that they are induced to avoid the internodes and take up their positions at the points of comparative rest of the vibrating rod, with which they are doubtless at first in immediate contact.

We have noticed in describing the form of the adult discorhabd in our two species that the chief specific distinction lies in the fact that in *Latrunculia bocagei* (fig. 7) the apex is broadly rounded and provided with a number of capitate spines, while in *L. apicalis* (figs. 20, 21) it is drawn out into a long, slender, tapering end-piece. This difference is obviously to be attributed to the different behaviour of the protorhabd during development in the two cases. In *Latrunculia bocagei* the protorhabd appears to have finished its growth completely by the time that the deposition of silica commences, so that first the apical and then the basal extremity becomes completely enveloped. Growth in length of the spicule as a whole is no longer possible except for the very slight amount due to the thickening of the silica deposit at each end. In *L. apicalis*, on the other hand, the protorhabd continues to grow apically for a long time after all the thickenings of the shaft have made their appearance. Apparently the original apical thickening never completely envelops the end of the protorhabd, which goes on elongating until it has become about twice as long as it was when the deposition of silica first com-

menced. This forward growth is very clearly shown in fig. 16, representing a stage in which the terminal portion of the protorhabd projects quite freely beyond the apical knob. It is noteworthy that the uncovered portion of the protorhabd was deeply stained with borax-carmine, which had not been able to penetrate through the silica coating lower down. The deposition of silica follows the growth of the protorhabd, the final result being the long, tapering end-piece of the adult spicule.

The later stages in the development of the whorls are not easy to follow, owing to the difficulty of obtaining anything but a side view. In both species the median and the subsidiary whorl appear to consist normally of three segments, each derived from one of the three knobs which constitute the whorl in the young spicule. In the immature stages, however, there appears to be a good deal of variation in the number of these knobs, as will be seen by references to the figures. This apparent variation may be in part illusory and due to the concealment of one of the knobs behind the shaft. It does not seem to be entirely so, however, and it appears probable either that one or more segments of a whorl may be suppressed or that they do not necessarily all develop simultaneously. Such differences must depend upon differences either in the number or in the activity of the formative cells. How the knobs are transformed into the flattened segments of the adult whorl, with their beautifully crenate margins (fig. 24), is entirely unknown.

The apical whorl appears first as an equatorial ridge on the apical knob (figs. 6, 16, 18). This grows out into a disk, also with crenate margins (fig. 23) but not divided into segments. The mechanism of this development is again quite unknown, as also is that of the development of the various spines with which the apex and the manubrium are ornamented, but I am inclined to think that formative cells are again concerned as architects in these later stages, and it seems not impossible that, as already suggested, many formative cells may arise by division of the original ones.

The foregoing account of my observations on Latrunculia, though far from being complete, seems to justify the statement

that the development of a siliceous sponge-spicule is a far more complex process than is usually supposed, and that the course of events is determined by a combination of physical and biological factors. The protorhabd, the formative cells and the accessory silicoblasts all play their parts in bringing about the final result. That result appears to be primarily of a non-adaptive, one might almost say accidental, character, and in many cases the form of the spicule seems to remain entirely without significance from the utilitarian point of view. Should it happen to be useful for some particular purpose, however, the sponge is not slow to make use of it, and in some mysterious way arranges the spicules in the most suitable manner. In some cases a useful form is no doubt fostered and improved under the influence of natural selection, and that may be true of the very remarkable discorhabds which we have been considering. The perfect adaptation of the manubrium as an organ for the fixation of the spicule in the fibrous cortex of the sponge certainly suggests the operation of this factor, but it seems very improbable that natural selection can have had anything to do with the remarkable specific differences between the apices of these spicules in *Latrunculia bocagei* and *L. apicalis*. Still less can we suppose that natural selection is responsible for the difference in the position of the median whorl in the two species, which we have seen to be attributable to purely mechanical causes. In short, we may, I think, conclude that the facts which I have submitted for your consideration this evening afford considerable evidence in favour of the view that the characters by which one species is separated from another are usually of little or no importance to their possessor in the struggle for existence, while adaptations are usually shared by many different species.

Description of Plates 15–17.

Figs. 1–7. *Latrunculia bocagei* Ridley and Dendy.

Fig. 1. Protorhabd, with whorl of formative cells (*f.c.*) near the middle. × 1,900.

,, 2. Young spicule with two rings of formative cells (*f.c.*) and apical and median thickenings commencing. × 1,900.

Fig. 3. Slightly later stage, showing commencement of subsidiary thickening in the middle of the upper ring of formative cells; *sh.* sheath. × 1,900.

,, 4. Later stage, showing commencement of manubrium (*mn.*), formation of silica pockets by the formative cells, and accessory silicoblast (*a.s.*). × 1,900.

,, 5. Slightly later stage, with two distinct rings of silica pockets (*s.p.*). × 1,900.

,, 6. Later stage, with the median (*m.w.*) and subsidiary whorl (*s.w.*) represented each by three solid, conical projections. × 1,050.

,, 7. Fully developed or nearly fully developed spicule, lying in the mesogloea, with accessory silicoblast and other cells; *a.w.* apical whorl, other lettering as before. × 1,050.

Figs. 8–24. *Latrunculia apicalis* Ridley and Dendy.

,, 8. Protorhabd. × 1,050.

,, 9. Young spicule with basal (manubrium, *mn.*) and apical (*a.w.*) but no median thickening. × 1,050.

Figs. 10–13. Young spicules with basal, apical and median thickenings (figs. 9–12 also show commencement of apical growth). × 1,050.

Fig. 14. Stage with well-developed basal and apical thickenings and median whorl of three knobs (two only visible); also showing the sheath (*sh.*) and an accessory silicoblast (*a.s.*). The apical prolongation has been broken short. × 1,780.

,, 15. Stage in which the median (*m.w.*) and subsidiary whorl (*s.w.*) are each represented by (probably) three knobs of silica, which appear to have been formed in silica pockets of the sheath (*sh.*). The median whorl is displaced towards the manubrium (*mn.*). An accessory silicoblast is present (*a.s.*). × 1,780.

,, 16. Young spicule showing very clearly the apical growth of the protorhabd (*pr.*), which projects freely beyond the limit of the silica deposit and is also visible as an

axial thread throughout the length of the shaft. × 1,780.

Fig. 17. Young spicule with subsidiary whorl developed between the median and basal whorls, instead of, as usual, between the median and apical whorls. × 1,050.

,, 18. Stage in which the median and subsidiary whorls are represented by rings of conical projections; with accessory silicoblast (*a.s.*). × 1,050.

,, 19. Stage showing the appearance of the second subsidiary whorl (*s.w.* 2) on the apical prolongation; other lettering as before. × 1,050.

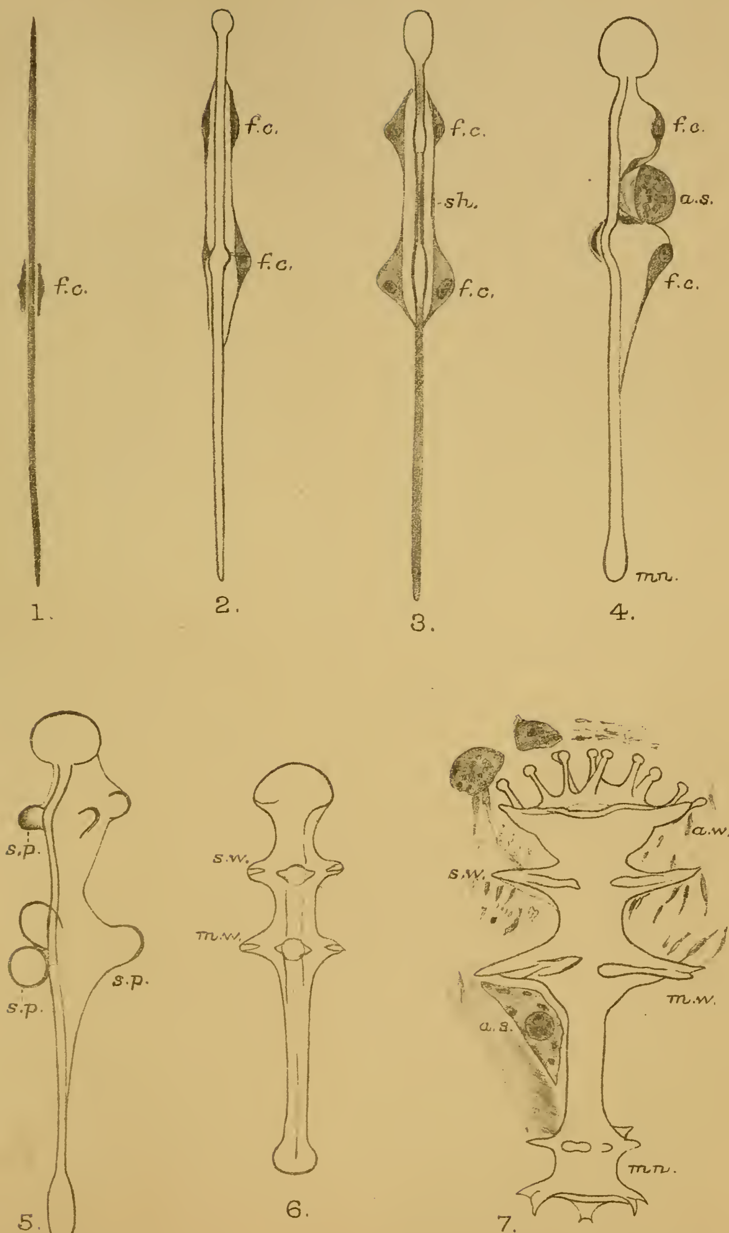
,, 20. Fully developed or nearly fully developed spicule; *a.p.*, apical prolongation, other lettering as before. × 1,050.

,, 21. Fully developed spicule in which the chief subsidiary whorl is missing. × 1,050.

,, 22. Abnormal spicule with branch coming off from apical prolongation and chief subsidiary whorl imperfect. × 1,050.

,, 23. Apical whorl of a fully developed spicule. × 1,050.

,, 24. Median whorl of a fully developed spicule. × 1,050.



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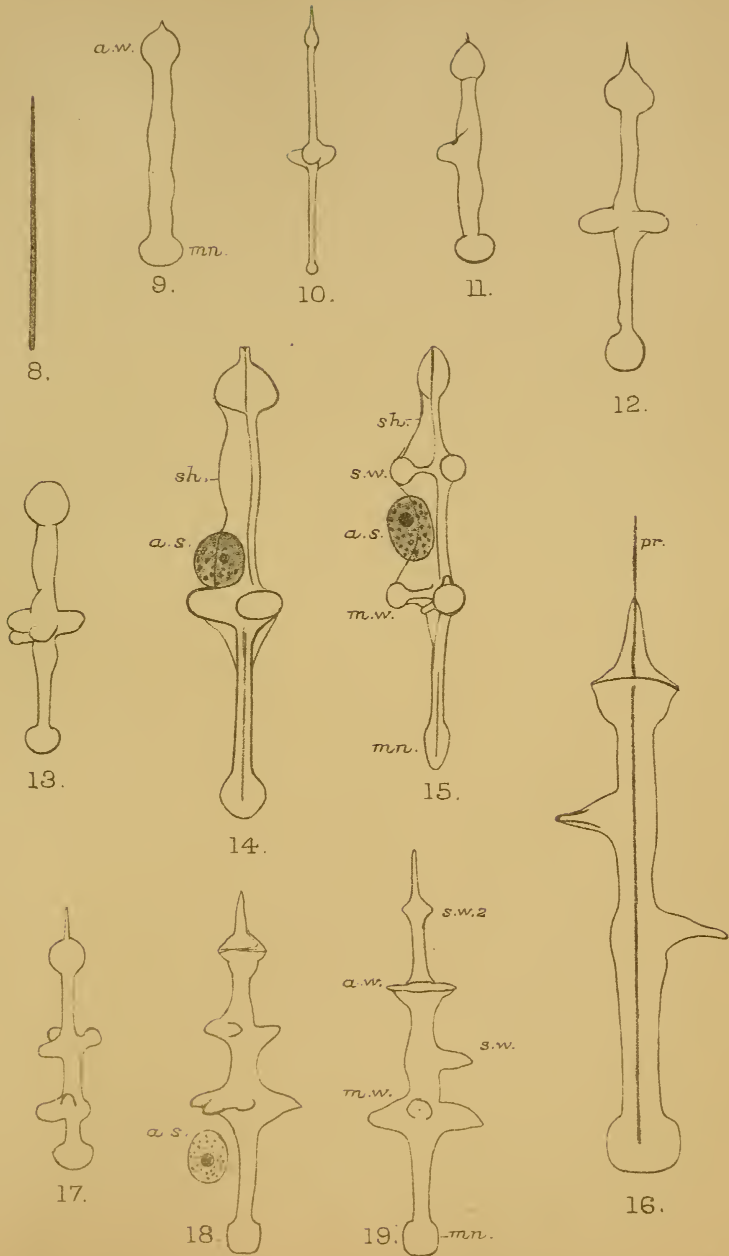
Development of Discorhabd in *Latrunculia bocagei* R. & D.



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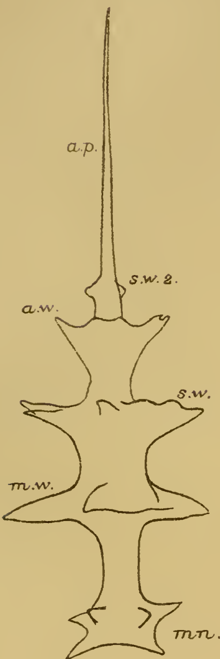
Development of Discorhabd in *Latrunculia apicalis* R. & D.



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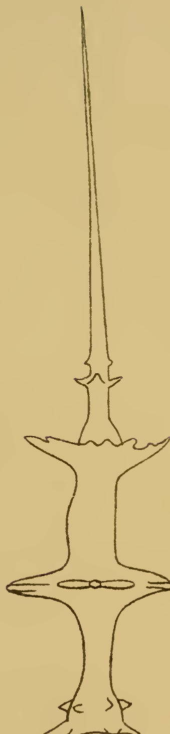

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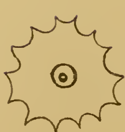

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Arthur Dendy del.

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The Discorhabd of *Latrunculia apicalis* R. & D.

THE DESMID FLORA OF DARTMOOR.

By G. T. Harris.

Communicated by J. Burton.

(*Read March 27th*, 1917.)

Plates 18, 19.

The Desmid flora of Dartmoor does not seem to have received much attention if one may judge by the literature dealing with it. E. Parfitt published a paper in the *Transactions of the Devonshire Association* (1) on the Devon Freshwater Algae, in which is given a list of the desmids then known to occur in the county. In this list of eighty-five species only nine are definitely stated to have been collected on Dartmoor, though it is probable that many of the species in Mrs. Griffiths' collection were obtained from Dartmoor localities. A. W. Bennett in the *Journal of the Royal Microscopical Society* (2) published a list of the species of Freshwater Algae collected by him in Hampshire and Devonshire in 1888 and 1889, the month being August in each year. In this paper he gives a list of forty-six species and varieties of desmids collected in the neighbourhood of Bovey Tracey and Buckfastleigh, but what species were collected on Dartmoor itself is not stated, merely a statement that the Dartmoor gatherings were very poor "both in individuals and species." Miss Joanna Town has published (3) a list of desmids collected on Haytor Moor and Bovey Heathfield, but here again there is no indication of the species actually collected on the moor. In West's *Monograph of the British Desmidiaceae* (4) Dartmoor habitats are specifically mentioned in only a few instances, though the records for the county may possibly include Dartmoor localities.

The section of Dartmoor dealt with in the present paper is the great central portion comprised between Cawsand Beacon on the northern extremity of the moor, and Bellever Tor on the southern, with Metherall as its eastern boundary and Lydford as its western. This area is roughly a square of some one

hundred and forty-four square miles of unclaimed more or less trackless moorland, broken with the principal tors for which Dartmoor is famed, and which rise to just above 2,000 feet in the northern portion. The whole surface is rolling and hilly, and the district dealt with here is practically an elevated plateau of about 1,100 feet altitude, from which rise the numerous hills and tors to a height totalling from 1,600 to 2,040 feet. The entire district forms the principal catchment area of the Devonshire water supply, and is covered with innumerable bogs and rivulets which feed the rivers Dart, Teign, Tavy, Taw and Okement, all of which have their head-waters in the higher portion around the desolate waste of Cranmere. The bogs vary in size and depth, and range from one of about thirty by twenty yards on the one hand to the dangerous and extensive areas of Raybarrow Mire in the northern portion and Fox Tor Mire in the southern. Generally speaking, the bogs are confined to the elevated plateau from which the higher portions of Dartmoor rise, or to the lower slopes of these eminences, while small moor pools and deep peat gullies are to be found on the higher portions. Vast deposits of peat resting on a granite floor characterise the whole district, even to the highest points of the moor, and as a consequence the streams and bogs after even slight rain become flooded with peaty water.

In collecting over this area it was divided into five districts for convenience in working, and these five constitute the divisions used in the census table of species accompanying this paper. It is obvious that in a district with so many individual bogs as Dartmoor possesses, it would be impracticable to enumerate the species of each bog separately, hence I have adopted the plan of grouping the bogs into districts formed as naturally as possible. The following short descriptions of the grouping may be useful for reference, the numerals being those of the districts in the table of species.

I. Metherall.—This is the name of a moorland farm on the eastern fringe of the moor, standing near the South Teign river. The bogs in the district are principally on the long slope of Water Hill which rises to the south, and that portion of moorland known as Chagford Common. Other bogs are situated on

Assycombe Hill, yet others are on the eastern slope of Long Ridge. On the northern side of the South Teign river the bogs extend up the slopes of Thornworthy Tor. All these bogs drain into the South Teign river or its tributaries. The Metherall district is bounded on the south by Water Hill, south-west by Assycombe Hill, west by Long Ridge and north by Thornworthy Tor, and forms a very natural basin. The average altitude of the bogs is about 1,250 feet.

II. Gidleigh.—This district is bounded on the north by Cawsand Beacon, on the south by Thornworthy and Kestor, on the west by Watern Tor and on the south-west by White Horse Hill. In it is situated one of the two principal bogs of the moor, the well-known Raybarrow Mire. This bog streams down the southern slope of Cawsand Beacon, past Kennon Hill and Ruelake Pit until it reaches the Wallabrook on Gidleigh Common near its junction with the North Teign river, altogether a distance of about three miles. More or less connected with this vast bog are those on the slopes of Hound Tor to the north-west and Watern Tor to the west. These important bogs drain into the North Teign river and its tributary the Wallabrook, and make it one of the best collecting districts on the moor. South of the North Teign river are the bogs on Shovel Down which drain Stanetor Hill. This district also forms a very natural basin with its bogs averaging from 1,200 to 1,300 feet in altitude.

III. Lydford.—This district on the western side of Dartmoor extends from Black Down on the fringe of the moor to the central ridge composed of the Cranmere and Cut Hill eminences where it joins with sections I and II. It is bounded on the north by Great and Little Links Tors and Amicombe Hill and extends to Nat Tor and Staindon Hill in the south. The bogs in this district drain into the rivers Lyd and Tavy and their tributaries. Compared with the other districts mentioned in this paper the bogs here are of less extent and the collecting altogether poorer. Their altitude ranges from about 900 feet on Black Down to 1,250 on Ger Tor.

IV. Haytor.—This section was less thoroughly worked than any of the others, owing chiefly to bad weather and limited time. The bogs examined were principally around Haytor, Rippon Tor

and Saddle Tor. Generally speaking, the bogs in this district are of small extent, but the yield in species is remarkably good. Here again the bogs are of an average altitude of from 1,200 to 1,300 feet.

V. Postbridge.—This, the southern limit of my collecting district, joins No. 1 (Metherall) at Water Hill in the north and extends to Bellever Tor in the south. On the east it is bounded by the huge rampart of Hamel Down, while Higher White, Lower White and Longford Tors mark its western extension. At Cut Hill, practically the centre of Dartmoor, the Postbridge district joins districts I and III. The district is drained by the East and West Dart and the small streams Cherrybrook, Lade and the southern Wallabrook. At least two important bogs occur in this district, Merripit and Broad Down, while another, Sousson's Bottom, though of less extent has proved an excellent collecting station. The whole district is thickly studded with bogs of greater or lesser extent, and from a collector's point of view ranks with the Gidleigh and Metherall districts as the best on the moor.

In district No. VI, Moor Pools, I have placed together the small moor pools situated above the altitudes at which the bogs occur, and which are completely isolated and not dependent for their water supply on drainage surfaces. These pools are not numerous on Dartmoor, and are of very small area (about thirty feet diameter), nevertheless they afford good and interesting collecting and I have thought it worth while to keep the results separate. They are nearly all above the 1,800 feet contour line and generally characterised by a profuse growth of *Sphagnum cuspidatum* var. *plumulosum*. The following table shows the result in species, varieties and " forms " of the various districts :

Table I.

District.	Species.	Varieties.	Forms.	Total.
I. Metherall . . .	200	52	11	263
II. Gidleigh . . .	194	39	18	251
III. Lydford . . .	137	29	6	172
IV. Haytor . . .	166	37	11	214
V. Postbridge . . .	199	47	16	262
VI. Moor Pools . . .	112	25	6	143

Some two hundred gatherings in all were made over the district described and the method of collecting and preserving the material has been described in a previous communication to the JOURNAL OF THE QUEKETT MICROSCOPICAL CLUB (5). With regard to those methods I may say that additional experience with them has proved their general usefulness and reliability. Material collected two years ago is still in a perfect state of preservation and available for further examination. Dr. Rendle has called attention to the value of copper salts for preserving the colour of chlorophyll (6) and Jörgensen has given an explanation of the chemical reactions involved (7). One rather striking feature has been noticed in the stored material. When the killing and fixing agent was first added to the gathering, and for months afterwards, no sign of life appeared, but during the last six or nine months micro-organisms have commenced to appear in increasing numbers although the amount of killing fluid added was sufficient to destroy life in all the aquatic larvae, Entomostraca, etc., present in the gathering. Richet has said that micro-organisms can acquire immunity towards certain antiseptics, which immunity can be transmitted. This would explain why subsequent additions of the fixing agent have failed to check the increase.

The material was collected during the months of July, August, September and October in 1915 and 1916. These two years in Devonshire were marked by long spells of dry and bright weather. In 1915 during five weeks' collecting on Dartmoor in August and September rain was experienced only for a few hours on three days, the rest of the time being almost unclouded sunshine. In 1916 an equally dry and bright period was experienced when collecting around Lydford in August. On this trip a moor-pool under Fur Tor at an altitude of about 1,877 feet was observed to have shrunk to such meagre dimensions that only a few gallons of water remained in the peaty bottom. The great heat experienced about that time had heated this residuum until it was quite tepid, yet abundant aquatic life was living in a congested state in it. Several individuals of *Dytiscus marginalis*, numerous species of Entomostraca and some sixty species and varieties of desmids were collected from it. It has

been said that strong sunlight is inimical to the life of the Chlorophyceae (8); but the condition of this pool would hardly support the statement, as a long spell of unclouded days had been experienced. The Postbridge material was collected the latter part of September and beginning of October 1916, and extremely adverse weather was experienced, the entire month spent there being wet and windy and the bogs becoming so swollen and saturated that it was almost impossible to get far into them. On this account I do not consider that the enumeration of species, etc., under this district in the census table quite fairly represents the richness of the locality. The rivers and mountain streams of Dartmoor were passed over entirely, as the bogs and moor pools were too numerous to permit of time being devoted to them. A test examination of the Dart at Postbridge (where it is a swift mountain stream) was, however, made and from a small gathering some fifty species and varieties were obtained, all common to the bogs situated higher up the river, from which they most probably came in periods of flushed streams.

In connection with the dispersal of desmids I would refer to the extent to which these plants are ingested by various forms of aquatic life. Larvae seem frequently to ingest them, and as I have noticed the desmid almost through the body of the larva with its chloroplasts still apparently uninjured it would seem that the secretions of the animal do not seriously affect the vitality of the desmid. In one rotifer I counted two individuals of *Tetmemorus granulatus*, two of *Tetmemorus Brébissonii* var. *minor*, two of *Staurastrum punctulatum* and one of *Staurastrum dejectum*. In one individual of a species of Euchlanis I counted the following desmids: three individuals of *Cosmarium Brébissonii*, two of *Tetmemorus granulatus*, one of *Micrasterias denticulata*, one of *Tetmemorus Brébissonii*, one *Euastrum ansatum*, one *Cosmarium difficile*, one *Staurastrum punctulatum*, one *Cosmarium subcrenatum* and one of *Tetmemorus Brébissonii* var. *minor*. In none of these as far as could be made out did there appear to be any digestion of the chloroplasts proceeding. Professor G. S. West suggests (9) that the armature of desmids has been developed as a protection against aquatic enemies, and while none of the species mentioned as having been ingested has

the highly developed system of spines of the furcate Staurastra, yet such a desmid as *Micrasterias denticulata* should be sufficiently formidable to secure immunity from attack. Frequent specimens of the larger desmids, more particularly of the genus Euastrum, have occurred from the Dartmoor bogs which were completely enveloped in hyaline cases. Such an one is figured on Plate 18, fig. 6. For some time I looked upon these cases as being due to a secretion of mucus by the desmid itself, but as the case was obviously a completely separate structure the solution did not appear to be very satisfactory. I was fortunate enough later to come across one of these hyaline cases containing two desmids, a specimen of *Cosmarium Brébissonii* and a species of Euastrum. It then occurred to me that the cases were probably secreted around the desmid (or desmids) in its passage through the alimentary canal of some aquatic animal owing to its inability to digest it.

In the field each collection, however unimportant the habitat, was kept separate and duly labelled. At home the various collections were worked out as individual units and the results entered in a field-book, so that it is possible to state exactly what species each station yielded. The various stations were then grouped under their respective districts. The result in species, varieties and forms from individual bogs varies with the extent and apparent age of the bog and shows some degree of constancy. That is to say, unimportant stations yielded from 70 to 80 records, average-sized bogs 120 to 130, while from the extensive and ancient bogs of the Raybarrow and Merripit type 230 records would be obtained. The total number of species, varieties and "forms" entered in my field-book for the district dealt with in this paper is considerably over four hundred; but as many species require careful re-examination, and as a considerable number of the Staurastra cannot at present be satisfactorily named, the total number given in the census table has been reduced to about four hundred. Furthermore, the material cannot yet be considered exhausted, as prolonged examination would certainly result in many additions to the list.

Zygospores are not infrequent in the Dartmoor gatherings.

One of the most prolific gatherings was made at Postbridge the second week in September from a small boggy ditch through which a stream of water slowly passed. The gathering was packed with zygospores of *Staurastrum punctulatum* Bréb., both type and its variety *Kjellmanni* Wille. Other genera and species were represented but not to the same extent. Professor G. S. West has stated that the end of September and beginning of October is the period most favourable to the production of zygospores, and the frequency with which they occur in the Postbridge gatherings confirms this statement. As the majority of them have already been described and figured I have made no specific mention of them, with the exceptions of the zygospores of *Cosmarium Brébissonii* and *Roya obtusa* var. *montana* West. These two zygospores have not been figured, though as West in the monograph of *The British Desmidiaceae* gives a reference to Archer (10) concerning the zygospore of *Cosmarium Brébissonii* I infer that some description of this zygospore is there given. It occurred in Haytor gatherings collected at the end of June, and several have been noticed. As will be seen from the figure (Pl. 19, fig. 10), it is globose and furnished with very short conical projections, and measures about 90 μ in diameter. The zygospore of *Roya obtusa* var. *montana* West (Pl. 19, fig. 11) is ellipsoid and smooth, with a measurement of 22 $\mu \times 15 \mu$. Kirchner states that the zygospore of the type (*Roya obtusa*) is globose and smooth.

W. and G. S. West have assigned a numerical standard indicative of the relative richness of desmid areas (11), and judged by it Dartmoor, with 280 species (certainly 300 when all are named) and about ninety varieties, must rank as one of the richest desmid areas of the British Isles. It is interesting in this connection to refer to some records from other areas. The plankton of the Irish lakes has a desmid census of 120 ; the Welsh lakes one of 113 ; the Scotch lakes one of 223 ; while the total Desmidiaceae of the British phyto-plankton is given as 236 species and 68 varieties (11). In the Dartmoor desmid-flora are to be found the following representatives of what W. and G. S. West consider western types of British Desmids : *Tetmemorus Brébissonii* var. *minor* ; *Euastrum pictum* (forma) ; *E. validum* ; *Cosmarium*

bipunctatum; *C. Corribense; C. pseudopyramidatum* var. *stenonotum; C. quadrifarium; C. subquadrans; C. tenue; C. tumidum; C. venustum; C. viride.* The following desmids, rare in even the richest areas, will be found recorded in the census list given later: *Netrium oblongum* var. *cylindricum; Penium exiguum; Closterium Ulna; Euastrum ventricosuum; E. pulchellum; E. pinnatum; Cosmarium connatum; C. decedens* var.; *C. elegantissimum; C. Nymmanianum; C. parvulum; C. pseudoconnatum; C. subundulatum; Staurastrum aculeatum; St. furcatum; St. inconspicuum; St. lanceolatum; St. pileolatum.* Some twenty species and varieties are now recorded for England for the first time, and about two hundred and fifty are new records for Devonshire. The following table (Table II) shows the various genera represented on Dartmoor, with the number of species, varieties and "forms" in each genus and the percentage of British *species* (only) in each genus.

TABLE II.

Genus.	Species.	Varieties.	Forms.	Percentage of British Species.*
Gonatyzogon . . .	4	1	—	80%
Spirotaenia . . .	6	—	—	40%
Mesotaenium . . .	3	—	—	30%
Cylindrocystis . . .	4	1	—	66%
Netrium . . .	3	3	—	75%
Penium . . .	18	3	3	64%
Roya . . .	2	1	—	66%
Closterium . . .	32	12	—	53%
Pleurotaenium . . .	1	—	—	11%
Tetmemorus . . .	4	2	—	100%
Euastrum . . .	31	5	4	67%
Micrasterias . . .	5	5	1	22%
Cosmarium . . .	83	38	13	33%
Xanthidium . . .	7	1	—	46%
Arthrodesmus . . .	7	6	5	53%
Staurastrum . . .	61	14	3	36%
Cosmocladium . . .	1	—	—	Percentage not deducible.
Sphaerozosma . . .	5	—	—	
Hyalotheca . . .	2	—	—	
Desmidium . . .	2	—	—	
Gymnozyga . . .	1	—	—	
	282	92	29	

* Fractions of percentages omitted.

It will be seen from this table that several genera are very richly represented in the district under review. Euastrum with 67 per cent. of the total British species is somewhat striking when it is remembered that most of the species of this genus are among the rarest of English desmids. All the species of the genus Tetmemorus occur on the moor in profuse quantities, except perhaps *Tetmemorus minutus*. The genera Spirotaenia and Mesotaenium are certainly under-estimated owing to the difficulty of correctly diagnosing species of these genera. On the other hand the percentage of Cosmaria is very much lower than one would have expected considering the large number of British species. The genus Pleurotaenium is very poorly represented, and Docidium not at all. In the genus Staurastrum the percentage given in the list is altogether too low for the number of species actually occurring on the moor.

In connection with the obvious richness of Dartmoor as a desmid area it will be of interest to refer to a theory recently advocated in explanation of these prolific areas, viz. that "the rich desmid areas correspond geographically with the Pre-Cambrian and older Palaeozoic outcrops" (11). With respect to the age of the Dartmoor rocks Clayden states (12) that "it must not be forgotten that the moor [*i.e.* Dartmoor] has been a land surface ever since its superincumbent volcanic peaks first arose above the waves of the Devonian sea." Accepting this view of the geologists it will be seen that Dartmoor lends distinct support to the theory that the richest desmid areas are connected with areas older than the Carboniferous. The granite tors of Dartmoor rise high above the region in which the bogs abound, so that the drainage water of the bogs is largely derived from the older Palaeozoic formation which West considers essential in the constitution of a rich desmid area.

While it cannot be said that any decidedly new species has resulted from an examination of the Dartmoor bogs, several "forms," and possibly some varieties, are of sufficient interest to merit special mention. Professor G. S. West of Birmingham University has been good enough to look over drawings of desmids from the material collected and to indicate those possessing sufficient interest to make them worth reproducing. The figures

in the plates accompanying this paper contain practically only those indicated by him, and of these descriptive notes are given when necessary under the heading "Description of Plates." The nomenclature followed throughout in this paper is that adopted by W. and G. S. West in their *Monograph of the British Desmidiaceae* (4) as far as it is published. Unfortunately it includes but a small portion of the genus Staurastrum, and for the completion of the genus, and for genera such as Desmidium, Sphaerozosma, etc., I have had to rely on Cooke's *British Desmids* (14) Ralfs's *British Desmidieae* (15) and whatever papers I could procure supplementing these earlier works. It is for this reason that the Staurastrum section of the census table must be regarded as incomplete and more or less unsatisfactory. The species in the census table have been arranged alphabetically for convenience of reference.

It is my pleasing duty before closing this paper to acknowledge my indebtedness to those who have so generously given me assistance in its preparation. To Professor G. S. West, M.A., D.Sc., F.L.S., of Birmingham University, I am deeply indebted for his kindness in going through my drawings and notes at a period when he could ill spare the time, and sending me valuable criticisms thereon. Several members of the Quekett Microscopical Club have been extremely generous with their help: Mr. C. Turner and Mr. J. Wilson have kindly and patiently gone over gatherings of nearly all the principal bogs I have collected from, sending me lists whereby I have corroborated and extended my own; to Mr. C. D. Soar, F.L.S., and Mr. D. J. Scourfield, F.Z.S., and also to Mr. C. H. J. Sidwell, F.R.M.S., I owe thanks for lending me literature connected with the group that has been invaluable. Finally, I would ask The Quekett Microscopical Club to accept my thanks for the kindness it shows me in accepting this paper for the pages of its Journal.

Special Notes on Some Species

(5) *Gonatozygon pilosum* Wolle. This rare species appears to be confined on Dartmoor to the old and prolific bogs of Metherall, Gidleigh and Postbridge. It rarely occurs.

(9) *Spirotaenia minuta* Thur. Only three British stations are mentioned in West's Desmidiaceae for this desmid, one of them being in Cornwall.

(8) *Spirotaenia eboracensis* G. S. West. The only record hitherto is Professor G. S. West's of Cam Fell, W. Yorkshire (*Teste*, Professor G. S. West).

(11) *Spirotaenia trabeculata* A. Br. (*Teste*, Professor G. S. West). Lough Anna, Donegal, is the only British locality West gives for this desmid. A few specimens were collected from one of the Metherall bogs.

(12) *Mesotaenium De Greyi* Turn. Although it is stated that this species occurs, in common with most of the Mesotaenia, in mucilaginous masses on rock surfaces, it is met with on Dartmoor more or less free in the bogs.

(19) *Cylindrocystis minutissima* Turn. Lough Neagh. Ireland is the only British locality given for this desmid in West's *Desmidiaceae*. The Dartmoor specimens rather exceed the measurements given by West, being 15 $\mu \times 10$ μ.

(23) *Netrium interruptum* var. *sectum* W. and G. S. West. Hitherto only recorded from Westport, Co. Mayo.

(43) *Penium navicula* var. *crassum* W. and G. S. West, from Postbridge, is a variety which has so far only been recorded from the extreme north-west of Scotland (*Teste*, Professor G. S. West).

(34) *Penium exiguum* West is another species hitherto only recorded from the south-west of Scotland. It is widely spread on Dartmoor but very infrequent.

(46) *Penium spirostriolatum* Barker. This interesting desmid is generally distributed over Dartmoor and comparatively plentiful in some of the larger bogs.

(74) *Closterium incurvum* Bréb. This rare desmid was collected at one or two stations on Dartmoor, but appears to be more at home at a lower altitude, as I have collected it in large quantities in some of the small ponds of East Devon.

(58) *Closterium acerosum* (Schrank) Ehrenb. is another low-land species rarely occurring on Dartmoor, but abundant in the low-lying portions of the county.

(83) *Closterium Malinvernianum* De Not. The single locality for this species is, strictly speaking, not properly placed by being included in the Dartmoor list. It was collected from the perpendicular face of a dripping rock in Lydford Gorge, which is situated on the extreme western fringe of the moor. It is included, with *Cosmarium speciosum* to be mentioned later, in the present list to record it for the county, though as a matter of fact Lydford Gorge is so nearly a part of Dartmoor (as Tavy Cleave is in the same district) that any misrepresentation is not of a serious nature.

(87) *Closterium pusillum* var. *monolithum* Wittr. Typical *C. pusillum* does not occur in the British Isles and the varieties seem to be very rare. Gurnard's Head, Cornwall, is the only British station hitherto known for the variety *monolithum*.

(99) *Tetmemorus Brébissonii* var. *minor* De Bary. A northern desmid judging by the recorded stations, but one frequently found on Dartmoor.

(105) *Euastrum affine* Ralfs, forma *scrobiculata* Nordst (*Teste*, Professor G. S. West) is new to Britain (vide *British Desmidiaceae*, vol. ii. p. 18).

(114) *Euastrum crassum* var. *scrobiculatum* Lund. "A very characteristic variety of rare occurrence" (West in *British Desmidiaceae*).

(120) *Euastrum dubium* var. *Snowdoniense* (Turn.) West. Turner, who originally described this as a species under *E. Snowdoniense*, seems to have been the only one to record it. It is certainly present in several of the older Dartmoor bogs. West has now sunk it to varietal rank under *E. dubium*.

(139) *Euastrum validum* W. and G. S. West has hitherto only been recorded for the extreme north-west of Scotland.

(142) *Euastrum Webbianum* Turn. The diagnosis of this species is somewhat doubtful.

(250) *Cosmarium Ralfsii* var. *montanum* Racib. is a desmid only so far recorded from Carrautuohill, Co. Kerry. It is not uncommon on Dartmoor.

(278) *Cosmarium tenue* Arch. In the British Isles this species has only been recorded from Ireland. It is certainly rare on Dartmoor.

(213) *Cosmarium moniliforme* (Turp.) Ralfs. The type is quite rare on Dartmoor, but the form *panduriformis* Heimerl is extremely common.

(318) *Staurastrum Bieneanum* Rabenh. This desmid appears to be quite local on Dartmoor, but was frequent in Merripit bog. Typical specimens, however, were infrequent, and tetragonal forms quite as plentiful as the normal triangular.

(332) *Staurastrum ellipticum* West. Apparently confined to one bog in the Lydford district. This was a bog of some extent on the eastern slope of Hare Tor, above the Rattlebrook ; here it was in some abundance.

(343) *Staurastrum grande* Bulnh. var. *parvum* West. Only one or two specimens were observed of this desmid from the extensive Merripit bog.

(380) *Staurastrum striolatum* (Näg.) Arch. Typical *St. striolatum* occurs generally on Dartmoor, but is very infrequent even in the bogs in which it occurs.

(329) *Staurastrum dispar* (Bréb.). *Teste*, Professor G. S. West. Roy seems to have been the only one to record this species for English stations. It is somewhat frequent on Dartmoor in the larger bogs.

(314) *Staurastrum alternans* var. *pulchrum* Wille. *Teste*, Professor G. S. West. Apparently a northern variety recorded by West from the north of Scotland.

(377) *Staurastrum retusum* Turn. var. *boreale* W. and G. S. West. *Teste*, Professor G. S. West. This small species appears to have been known hitherto only from the Orkney and Shetland Islands. It is very rare on Dartmoor and occurred only in two places at a considerable elevation.

(275) *Cosmarium tatricum* var. *sphaeruliferum* West. So far this desmid has only been recorded from Co. Galway.

(192) *Cosmarium furcatospermum* W. and G. S. West. This species, only recorded by West from the Orkneys and Lough Neagh, occurs very sparingly in some of the

Dartmoor bogs. For some time I confused it with *C. sphalerostichum* Nordst. until a careful examination of empty cells changed my opinion. Professor G. S. West says of a drawing, "Probably *C. furcatospermum*."

(236) *C. punctulatum* var. *granulusculum* (Roy and Bissett) West. The authors of the *British Desmidiaceae* state that they have never seen any specimens of this variety. I have had from Metherall and Postbridge gatherings several empty cells which exactly agreed with the description and figure given from Roy and Bissett in West's monograph, and it certainly seems an equally distinctive variety with Klebs' *C. punctulatum* var. *rotundatum*.

(162) *Cosmarium bipunctatum* var. *subrectangularis* West. A Hebridean variety (*Teste*, Professor G. S. West).

(259) *Cosmarium speciosum* Lund. This species from Lydford Gorge,

(260) and also its variety *Rostafinskii* have a doubtful claim to be considered as Dartmoor desmids on account of their habitats, but are included in order that they may be recorded for the county. (See ante, *Closterium Malinvernianum*.)

(177) *Cosmarium crenatum* forma *Boldtiana* (Gutw.) West. Apparently a very rare form only recorded by Roy and Bissett from Scotland.

(291) *Xanthidium armatum* var. *irregularis* West. An Irish variety which occurs very infrequently in several of the older Dartmoor bogs.

(294) *Xanthidium Robinsonianum* Arch. This rare desmid occurred in profusion in a small moor pool on White Horse Hill at an altitude of about 1,800 feet. A few specimens were also obtained from one of the bogs at Postbridge.

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DESCRIPTION OF PLATES.

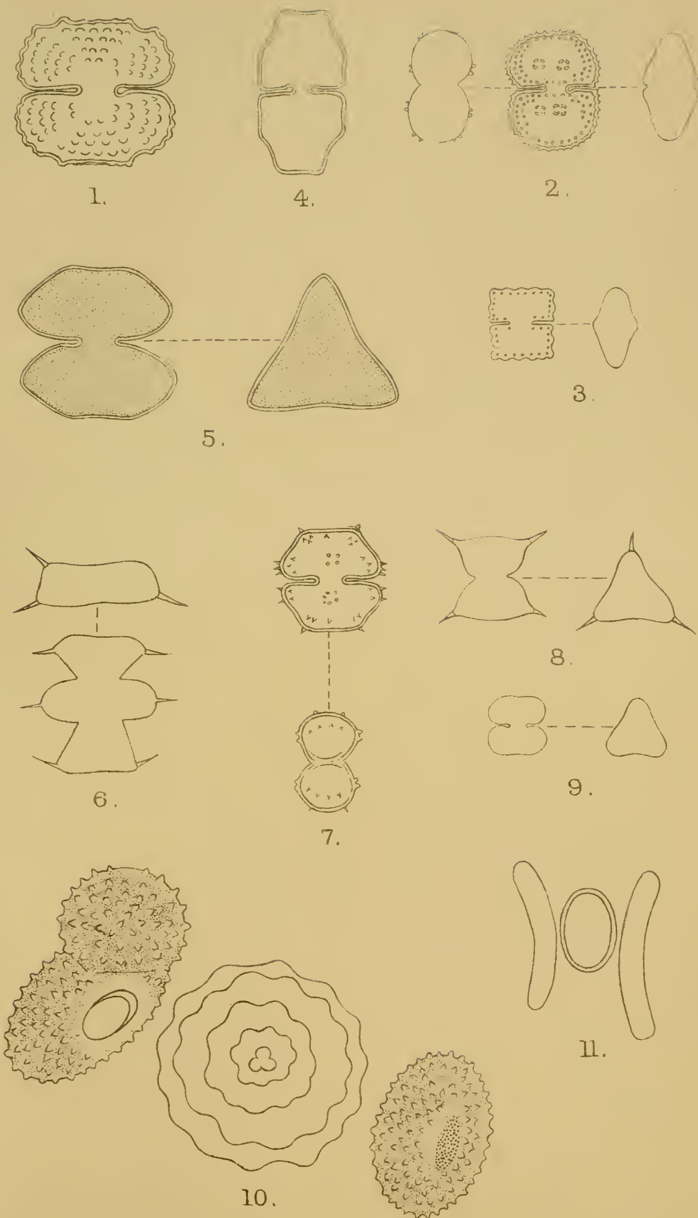
PLATE 18.

Fig. 1. *Euastrum oblongum* (Grev.) Ralfs, forma nov. This new form from Metherall bog has the apices of the polar lobe truncate and not convex; the lateral lobes are more retuse than in the type. × 300.

[illegible] del. ad nat.

Adlard & Son & West Newman Ltd.

Desmid Flora of Dartmoor.



G. T. Harris del. ad nat.

Adlard & Son & West Newman Ltd.

Desmid Flora of Dartmoor.

Fig. 2. *Euastrum* (monstrosity) from Teignhead bog. The lower semi-cell of this plant is typical *Euastrum Didelta* (Turp.) Ralfs, while the upper semi-cell if not *Euastrum humerosum* Ralfs is a very close approximation. × 300.

,, 3. *Euastrum affine* Ralfs, forma *scrobiculata* Nordst. See note (105) p. 259. × 510.

,, 4. *Euastrum pictum* Börg. forma. × 510.

,, 5. *Euastrum crassum* (Bréb.) Kutz. var. *scrobiculatum* Lund.

,, 6. *Euastrum oblongum* (Grev.) Ralfs. Specimen in hyaline case. × 300.

,, 7. *Euastrum binale* (Turp.) Ehrenb. forma *secta* Turner. This form differs considerably in having the basal lobes sub-quadrate and a deeper incision between the basal and polar lobes. × 510.

,, 8. *Euastrum dubium* Näg. var. nov. 27 $\mu \times 18\ \mu$. This variety appears to be a much reduced form, with the lobulation of the basal lobes less developed and the conical granules of the polar lobe wanting. × 510.

,, 9. *Cosmarium subquadratum* Nordst. × 510.

,, 10. *Cosmarium formosulum* Hoff. × 510.

Plate 19.

Fig. 1. *Cosmarium ornatum* Ralfs form. × 510.

,, 2. *Cosmarium bipunctatum* (Börg.) forma *subrectangularis* West. The central papillae in most of the Dartmoor specimens are larger than in typical *C. bipunctatum* and divided transversely, so that they almost appear as four. × 510.

,, 3. *Cosmarium lepidum* West. var. × 510.

,, 4. *Cosmarium venustum* (Bréb.) Arch. "An unusual form," Professor G. S. West. × 510.

,, 5. *Staurastrum Bieneanum* Rabenh. form with markedly retuse apices. × 510.

,, 6. *Arthrodesmus Incus* Bréb. *var. Ralfsii* West. Monstrous form, with development of additional semi-cell. A

vertical view of supernumerary semi-cell; B, front view of cell. × 510.

Fig. 7. *Xanthidium Robinsonianum* Arch. forma. × 510.

,, 8. *Staurastrum O'Mearii* Arch. forma. × 510.

,, 9. *Staurastrum retusum* Turn. var. *boreale* W. and G. S. West. × 510.

,, 10. Zygospore of *Cosmarium Brébissonii* Menegh. × 310.

,, 11. Zygospore of *Roya obtusa* var. *montana* W. and G. S. West. × 510.

CENSUS OF DESMIDS FOUND ON DARTMOOR

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
Order *CONJUGATAE.*							
Family DESMIDIACEAE.							
Sub-family SACCODERMAE.							
Genus **Gonatozygon** De Bary, 1856.							
1. G. Brébissonii *De Bary* . .	R.	×				×	
2. G. Brébissonii var. minutum *W. and G. S. West*	R.	×	×	×			
3. G. Kinahani (*Arch.*) *Rabenh.* .	F.		×	×	×	×	×
4. G. monotaenium *De Bary* . .	F.	×	×	×	×	×	
5. G. pilosum *Wolle* . . .	V.R.	×	×			×	
Genus **Spirotaenia** Bréb. 1848.							
6. S. acuta *Hilse*	V.R.		×		×		
7. S. condensata *Bréb.* . . .	F.	×	×	×	×	×	×
8. S. eboracensis *G. S. West* . .	V.R.	×					
9. S. minuta *Thur.*	R.		×	×	×		
10. S. parvula *Arch.*	R.		×	×	×		×
11. S. trabeculata *A. Br.* . . .	V.R.	×					
Genus **Mesotaenium** Näg. 1849.							
12. M. De Greyi *Turn.*	R.			×	×		
13. M. macrococcum (*Kütz*) *Roy and Bissett*	R.			×		×	
14. M. Kramstai *Lemm.* . . .	R.				×		
Genus **Cylindrocystis** Menegh. 1838.							
15. C. Brébissonii *Menegh.* . .	C.	×	×	×	×	×	×
16. C. Brébissonii var. minor *W. and G. S. West*	V.R.			×	×	×	
17. C. crassa *De Bary* . . .	C.	×	×	×	×	×	×
18. C. diplospora *Lund.* . . .	F.	×	×	×		×	×
19. C. minutissima *Turn.* ($15\mu \times 10\mu$)	R.		×	×			

V.C. = Very Common. C.= Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
Genus **Netrium** (Näg. 1849).							
20. N. Digitus (*Ehrenb.*) *Itzigs. and Rothe*	V.C.	×	×	×	×	×	×
21. N. Digitus var. constrictum *W. and G. S. West*	F.	×	×	×	×	×	×
22. N. interruptum (*Bréb.*) *Lütkem.* .	F.	×	×	×	×	×	
23. N. interruptum var. sectum *W. and G. S. West*	V.R.	×					
24. N. oblongum (*De Bary*) *Lütkem.* .	V.C.	×	×	×	×	×	×
25. N. oblongum var. cylindricum *W. and G. S. West* . . .	F.	×		×	×	×	×
Sub-family PLACODERMAE.							
Genus **Penium** Bréb. 1844.							
26. P. cruciferum (*De Bary*) *Wittr.* .	F.	×		×	×	×	×
27. P. cuticulare *W. and G. S. West*	C.		×	×	×	×	×
28. P. curtum *Bréb.*	R.	×	×			×	
29. P. curtum forma minuta *West* ($21{\cdot}25\mu \times 9{\cdot}5\mu$) . . .	V.R.					×	
30. P. cucurbitinum *Biss.* . .	F.	×	×	×	×	×	×
31. P. cucurbitinum forma minor *W. and G. S. West* . . .	R.		×	×		×	
32. P. Cylindrus (*Ehrenb.*) *Bréb.* .	F.	×	×	×	×	×	
33. P. didymocarpum *Lund.* . .	F.	×	×	×	×	×	×
34. P. exiguum *West* . . .	R.	×	×	×	×	×	×
35. P. exiguum forma major *W. and G. S. West*	V.R.				×		
36. P. Libellula (*Focke*) *Nordst.* .	F.	×	×	×	×	×	
37. P. Libellula var. interruptum *W. and G. S. West* . . .	F.	×		×	×	×	×
38. P. Libellula var. intermedium *Roy and Biss.*	R.	×	×			×	
39. P. Mooreanum *Arch.*	V.R.		×				
40. P. minutum (*Ralfs*) *Cleve* . .	F.	×	×	×	×	×	
41. P. margaritaceum (*Ehrenb.*) *Bréb.*	R.	×			×	×	
42. P. Navicula *Bréb.*	C.	×	×	×	×	×	×
43. P. Navicula var. crassum *W. and G. S. West*	V.R.			×		×	
44. P. polymorphum *Perty* . .	R.	×		×		×	
45. P. phymatospermum *Nordst.* .	V.R.			×			×
46. P. spirostriolatum *Barker* . .	F.	×	×		×	×	×
47. P. spinospermum *Josh.* . .	R.	×		×	×	×	
48. P. subtile *W. and G. S. West* .	V.R.	×			×		
49. P. truncatum *Bréb.*	R.	×	×	×	×	×	×
Genus **Roya**. *W and G. S. West*, 1896.							
50. R. obtusa (*Bréb.*) *W. and G. S. West*	R.				×	×	

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
51. R. obtusa var. montana *W. and G. S. West*	R.	×				×	×
52. R. Pseudoclosterium (*Roy*) *W. and G. S. West*	R.	×	×		×	×	
Genus **Closterium** Nitzsch, 1817.							
53. C. abruptum *West* . . .	C.	×	×	×	×	×	×
54. C. abruptum var. brevius *W. and G. S. West*	F.	×	×	×	×	×	×
55. C. acutum (*Lyngb.*) *Bréb.* . .	F.	×	×	×	×	×	
56. C. acutum var. linea *W. and G. S. West*	V.R.				×		
57. C. aciculare *Tuffen West* . .	V.R.	×	×				
58. C. acerosum (*Schrank*) *Ehrenb.* .	V.R.	×		×		×	
59. C. angustatum *Kütz.*	R.	×	×			×	
60. C. Archerianum *Cleve* . . .	F.	×	×		×	×	×
61. C. attenuatum *Ehrenb.* . .	R.	×			×	×	
62. C. Cornu *Ehrenb.* . . .	R.	×	×		×	×	×
63. C. costatum *Corda* . . .	C.	×	×	×	×	×	×
64. C. Cynthia *De Not.* . . .	R.	×		×		×	×
65. C. Dianae *Ehrenb.* . . .	C.	×	×	×	×	×	
66. C. Dianae var. arcuatum (*Bréb.*) *Rabenh.*	R.		×		×	×	
67. C. didymotocum *Corda* . .	F.	×	×	×	×	×	
68. C. Ehrenbergii *Menegh.* . .	F.	×	×	×		×	
69. C. gracile *Bréb.*	R.	×	×		×		
70. C. gracile var. tenue (*Lemm.*) *W. and G. S. West* . . .	F.	×			×	×	
71. C. gracile var. elongatum *W. and G. S. West*	V.R.	×			×		
72. C. intermedium *Ralfs* . .	F.	×	×	×	×	×	
73. C. intermedium var. hibernicum *West*	V.R.			×			
74. C. incurvum *Bréb.* . . .	R.			×		×	
75. C. Jenneri *Ralfs* . . .	C.	×	×	×	×	×	
76. C. Jenneri var. robustum *G. S. West*	F.	×	×			×	×
77. C. juncidum *Ralfs* . . .	C.	×	×	×	×	×	
78. C. juncidum var. brevior *Roy* .	R.	×				×	
79. C. Lunula (*Müll.*) *Nitzsch* . .	C.	×	×	×	×	×	×
80. C. Lunula var. biconvexum *Schmidle*	V.R.		×			×	
81. C. lineatum *Ehrenb.*	C.	×	×	×	×	×	
82. C. parvulum *Näg.* . . .	C.	×	×	×	×	×	×
83. C. Malinvernianum *De Not.* .	V.R.			×			
84. C. parvulum var. angustum *W. and G. S. West*	V.R.	×	×				
85. C. Pritchardianum *Arch.* . .	F.	×	×	×	×	×	
86. C. pronum *Bréb.* . . .	V.R.					×	

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford III	Haytor. IV	Postbridge. V	Moorpools. VI
87. C. pusillum *Hantzsch* var. monolithum *Wittr.*	V.R.	×					
88. C. rostratum *Ehrenb.* . . .	F.	×	×	×	×	×	
89. C. Ralfsii *Bréb.* var. hybridum *Rabenh.*	V.R.					×	
90. C. striolatum *Ehrenb.* . . .	V.C.	×	×	×	×	×	×
91. C. setaceum *Ehrenb.* . . .	V.R.		×		×	×	×
92. C. subulatum (*Kütz.*) *Bréb.* . .	V.R.			×			×
93. C. tumidum *Johnson* . . .	R.	×	×		×	×	
94. C. toxon *West*	R.	×	×	×	×	×	
95. C. Ulna *Focke*	V.R.		×				
96. C. Venus *Kütz.*	R.	×	×			×	
Genus **Pleurotaenium** Näg. 1849.							
97. P. Ehrenbergii (*Bréb.*) *De Bary* .	F.	×	×	×	×	×	×
Genus **Tetmemorus** Ralfs, 1844.							
98. T. Brébissonii (*Menegh.*) *Ralfs* .	C.	×	×	×	×	×	×
99. T. Brébissonii var. minor *De Bary*	F.	×	×	×	×	×	×
100. T. granulatus (*Bréb.*) *Ralfs* .	V.C.	×	×	×	×	×	×
101. T. granulatus var. attenuatus *West*	R.	×	×	×	×	×	
102. T. laevis (*Kütz.*) *Ralfs* . .	C.	×	×	×	×	×	
103. T. minutus *De Bary* . . .	R.	×	×	×	×		×
Genus **Euastrum** Ehrenb. 1832.							
104. E. affine *Ralfs*	F.	×	×	×	×	×	×
105. E. affine forma scrobiculata *Nordst.**	V.R.					×	
106. E. ampullaceum *Ralfs* . .	F.	×	×	×	×	×	×
107. E. ansatum *Ralfs* . . .	V.C.	×	×	×	×	×	×
108. E. binale (*Turp.*) *Ehrenb.* . .	V.C.	×	×	×	×	×	×
109. E. binale forma secta *Turn.* .	C.	×	×	×	×	×	×
110. E. binale forma hians *West* .	C.	×	×	×	×	×	×
111. E. binale forma Gutwinskii *Schmidle*	C.	×	×	×	×	×	×
112. E. bidentatum *Näg.* . . .	F.	×	×		×	×	×
113. E. crassum (*Bréb.*) *Kütz.* . .	C.		×	×	×	×	×
114. E. crassum var. scrobiculatum *Lund.*	V.R.		×				
115. E. crispulum (*Nordst.*) *W. and G. S. West*	V.R.	×					
116. E. cuneatum *Jenner* . . .	F.		×	×		×	×
117. E. denticulatum (*Kirchn.*) *Gay* .	F.	×	×		×	×	×
118. E. Didelta (*Turp.*) *Ralfs* . .	V.C.	×	×	×	×	×	×
119. E. dubium *Näg.*	C.	×	×	×	×	×	×
120. E. dubium var. Snowdoniense (*Turn.*) *West*	R.	×	×			×	×

* *Vide* Pl. 18, fig. 3.

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
121. E. elegans (*Bréb.*) *Kütz.* . .	C.	×	×	×	×	×	×
122. E. elegans var. Novae Semliae *Wille*	V.R.	×				×	
123. E. erosum *Lund.* . . .	V.R.	×					
124. E. gemmatum *Bréb.* . . .	V.R.	×			×		
125. E. humerosum *Ralfs* . . .	R.	×	×	×	×		
126. E. insigne *Hass.* . . .	F.	×	×	×		×	×
127. E. inerme (*Ralfs*) *Lund.* . .	V.R.					×	
128. E. insulare (*Wittr.*) *Roy* . .	F.	×	×	×	×	×	×
129. E. montanum *W. and G. S. West*	F.	×	×	×	×	×	×
130. E. oblongum (*Grev.*) *Ralfs* . .	C.	×	×		×	×	×
131. E. pinnatum *Ralfs* . . .	R.		×		×	×	
132. E. pulchellum *Bréb.* . . .	V.R.	×	×			×	×
133. E. pectinatum *Bréb.* . . .	C.	×	×	×	×	×	×
134. E. pectinatum var. inevolutum *W. and G. S. West* . .	R.	×			×	×	
135. E. pictum *Borg.* forma * . .	V.R.		×				
136. E. rostratum *Ralfs* . . .	F.	×	×			×	
137. E. sinuosum *Lenorm.* . .	V.R.	×	×				×
138. E. sublobatum *Bréb.* . . .	V.R.		×		×	×	
139. E. validum *W. and G. S. West* .	V.R.		×				
140. E. ventricosum *Lund.* . .	R.	×		×		×	
141. E. verrucosum *Ehrenb.* . .	V.R.					×	
142. E. Webbianum *Turn.* † . .	V.R.		×				
Genus **Micrasterias** Ag. 1827.							
143. M. crenata *Bréb.* . . .	V.R.		×				
144. M. denticulata *Bréb.* . . .	V.C.	×	×	×	×	×	×
145. M. denticulata var. angulosa (*Hantzsch*) *W. and G. S. West*	R.				×	×	
146. M. denticulata var. notata *Nordst.*	R.	×			×	×	×
147. M. Jenneri *Ralfs* var. simplex *West*	V.R.		×				
148. M. oscitans *Ralfs* var. mucronata (*Dixon*) *Wille* . . .	F.	×	×	×	×	×	×
149. M. papillifera *Bréb.* . . .	F.	×	×	×	×	×	×
150. M. papillifera var. glabra *Nordst.*	R.	×					
151. M. rotata (*Grev.*) *Ralfs.* . .	V.C.	×	×	×	×	×	×
152. M. rotata forma evoluta *Turn.* .	R.		×		×	×	
153. M. truncata (*Corda*) *Bréb.* .	F.	×	×	×	×	×	
Genus **Cosmarium** Corda, 1834.							
154. C. abbreviatum *Racib.* forma minor *W. and G. S. West* . .	V.R.				×		
155. C. annulatum (*Näg.*) *De Bary* .	V.R.	×					
156. C. amaenum *Bréb.* . . .	V.R.		×				

* *Vide* Pl. 18, fig. 4. † *Vide* p. 259.

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
157. C. arctoum *Nordst.* var. tatricum *Racib.*	V.R.	×		×			
158. C. bioculatum *Bréb.*	R.		×				
159. C. bioculatum forma depressa *Schaarschm.*	V.R.				×		
160. C. bioculatum var. hiaus *W. and G. S. West*	R.		×	×		×	×
161. C. bipunctatum *Börg.*	F.	×	×	×	×	×	×
162. C. bipunctatum forma subrectangularis *West* *	R.		×			×	×
163. C. Botrytis *Menegh.*	F.	×			×	×	
164. C. Botrytis var. emarginatum *Hansg.*	V.R.				×		
165. C. Brebissonii *Menegh.*	V.C.	×	×	×	×	×	×
166. C. Blyttii *Wille*	V.C.	×	×	×	×	×	
167. C. Blyttii var. Novae Sylvae *W. and G. S. West*	F.	×			×	×	×
168. C. caelatum *Ralfs*	F.	×		×	×	×	×
169. C. connatum *Bréb.*	R.		×		×		
170. C. coarctatum *West*	V.R.	×			×		
171. C. contractum *Kirchn.*	R.		×	×	×		
172. C. contractum var. ellipsoideum (*Elfv.*) *West*	R.					×	
173. C. contractum var. ellipsoideum forma retusa *West*	R.	×	×		×		
174. C. contractum var. Gartanense *W. and G. S. West*	V.R.			×	×	×	
175. C. Corribense *W. and G. S. West*	V.R.					×	
176. C. crenatum *Ralfs*	C.	×	×	×	×	×	×
177. C. crenatum forma Boldtiana (*Gutw.*) *West*	R.	×	×			×	
178. C. Cucurbita *Bréb.*	V.C.	×	×	×	×	×	×
179. C. Cucurbita var. attenuatum *G. S. West*	V.R.		×				
180. C. Cucurbita forma latior, *W. and G. S. West*	V.R.						×
181. C. Cucumis (*Corda*) *Ralfs*	R.	×	×		×		×
182. C. Cucumis var. magnum *Racib.*	V.R.		×			×	×
183. C. cymatonotophorum *West*	V.R.	×	×				
184. C. depressum (*Näg.*) *Lund.*	R.	×	×			×	×
185. C. depressum var. achondrum (*Boldt.*) *W. and G. S. West*	F.	×	×	×	×	×	
186. C. difficile *Lütkem.*	F.	×	×	×	×	×	×
187. C. difficile var. sublaeve *Lütkem.*	R.	×	×			×	
188. C. exiguum *Arch.*	V.R.				×		
189. C. exiguum var. pressum *W. and G. S. West*	V.R.	×					

* *Vide* Pl. 19, fig. 2.

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190. C. elegantissimum *Lund.*	V.R.	×	×			×	
191. C. formosulum *Hoff.*	V.R.					×	
192. C. furcatospermum *W. and G. S. West*	R.	×	×	×	×	×	
193. C. galeritum *Nordst.*	V.R.	×					
194. C. Garrolense *Roy and Biss.*	R.	×	×			×	×
195. C. globosum *Bulnh.*	R.	×	×	×	×	×	×
196. C. globosum forma minor *Boldt.* (12·5 × 10μ)	V.R.					×	
197. C. globosum var. minus *Hansg.* (17 × 13μ)	V.R.					×	
198. C. goniodes *W. and G. S. West*	V.R.					×	
199. C. Hammeri *Reinsch.* var. homalodermum (*Nordst.*) *West*	V.R.		×		×		
200. C. Holmiense *Lund.* var. integrum *Lund.*	V.R.	×		×			
201. C. humile *Nordst.* var. substriatum *Schmidle*	V.R.		×		×		
202. C. humile var. glabrum *Gutw.*	V.R.	×	×			×	
203. C. impressulum *Elfv.*	F.			×	×	×	
204. C. inconspicuum *W. and G. S. West*	V.R.						×
205. C. isthmochondrum *Nordst.*	V.R.	×	×				×
206. C. laeve *Rabenh.*	C.	×	×	×	×	×	×
207. C. laeve var. octangularis (*Wille*) *W. and G. S. West*	V.R.		×	×			
208. C. laeve var. septentrionale *Wille*	R.	×	×		×		
209. C. Logiense *Bissett*	V.R.	×					
210. C. lepidum *West.* var. nov.*	V.R.	×					
211. C. margaritiferum *Menegh.*	F.	×	×		×	×	×
212. C. minimum *W. and G. S. West*	V.R.			×			
213. C. moniliforme (*Turp.*) *Ralfs*	V.R.	×			×	×	
214. C. moniliform forma panduriformis *Heimerl*	C.	×	×	×	×	×	
215. C. Meneghinii *Bréb.*	R.	×		×	×		×
216. C. nasutum *Nordst.*	V.R.	×					
217. C. Norimbergense *Reinsch.*	V.R.	×					×
218. C. Nymannianum *Grun.*	R.		×			×	
219. C. Novae Semliae *Wille* var. sibiricum *Boldt.*	V.R.	×	×				
220. C. notabile *Bréb.*	V.R.					×	
221. C. ochthodes *Nordst.*	F.	×	×	×		×	×
222. C. ochthodes var. amoebum *West*	V.R.	×				×	
223. C. ornatum *Ralfs*	R.	×			×	×	×
224. C. orthostichum *Lund.*	V.R.	×					
225. C. pachydermum *Lund.*	R.	×		×	×		
226. C. Palangula *Bréb.*	V.R.		×				

* *Vide* Pl. 19, fig. 3.

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
227. C. parvulum *Bréb.*	C.	×	×	×	×	×	
228. C. praemorsum *Bréb.*	V.R.	×			×		
229. C. prominulum *Racib.* var. subundulatum *W. and G. S. West*	V.R.			×			
230. C. polygonum (*Näg.*) *Arch.*	V.R.		×				
231. C. Portianum *Arch.*	V.R.	×				×	
232. C. Phaseolus *Bréb.* forma minor *Boldt.*	V.R.					×	
233. C. punctulatum *Bréb.*	V.C.	×	×	×	×	×	
234. C. punctulatum var. subpunctulatum *Borges*	C.	×	×	×	×	×	×
235. C. punctulatum var. rotundatum *Klebs*	V.R.	×	×				
236. C. punctulatum var. granulusculum (*Roy and Bissett*) *West*	V.R.	×				×	
237. C. pusillum (*Bréb.*) *Arch.*	F.	×	×	×	×	×	×
238. C. pseudopyramidatum *Lund.*	C.	×	×	×	×	×	×
239. C. pseudopyramidatum var. stenonotum *Nordst.*	V.R.	×					
240. C. pseudoconnatum *Nordst.*	F.	×		×	×	×	
241. C. pseudoexiguum *Racib.*	R.	×	×	×		×	×
242. C. pseudarctoum *Nordst.*	R.	×	×			×	
243. C. pygmaeum *Arch.*	V.C.	×	×	×	×	×	×
244. C. pyramidatum *Bréb.*	R.	×	×	×	×	×	
245. C. quadrimamillatum *W. and G. S. West*	V.R.	×		×			
246. C. Quadrum *Lund.*	V.R.		×				
247. C. quadrifarium *Lund.*	V.R.		×				
248. C. quadratulum (*Gay*) *De Toni*	V.C.	×	×	×	×	×	×
249. C. Ralfsii *Bréb.*	F.	×	×	×	×	×	×
250. C. Ralfsii var. montanum *Racib.*	F.	×	×	×	×	×	
251. C. reniforme (*Ralfs*) *Arch.*	F.	×	×		×	×	×
252. C. rectangulare *Grun.*	R.	×	×		×		
253. C. rectangulare var. cambrense (*Turn.*) *West*	V.R.				×		
254. C. Regnellii *Wille*	V.R.	×					
255. C. Regnesi *Reinsch*	V.C.	×	×	×	×	×	×
256. C. Regnesi var. tritum *West*	V.R.		×			×	
257. C. Regnesi var. montanum *Schmidle*	V.R.		×		×		
258. C. sexangulare *Lund.* forma minima *Nordst.*	V.R.		×				
259. C. speciosum *Lund.*	V.R.			×			
260. C. speciosum var. Rostafinskii	V.R.			×			
261. C. sphalerostichum *Nordst.*	V.C.	×	×	×	×	×	
262. C. Sportella *Bréb.*	F.	×	×	×	×	×	
263. C. Sportella var. subnudum *W. and G. S. West*	R.	×		×	×		
264. C. sphagnicolum *W. and G. S. West*	R.	×	×	×			×

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
265. C. succisum *West* . . .	V.R.	×				×	
266. C. subarctoum (*Lagerh.*) *Racib.* forma punctata *West* . .	V.R.	×					
266a. C. subarctoum (*Lagerh.*) *Racib.* forma minor *Nordst.* . .	V.R.		×				
267. C. subcrenatum *Hantzsch* . .	C.	×	×	×	×	×	×
268. C. subtumidum *Nordst.* . .	C.	×	×		×	×	×
269. C. subtumidum var. Klebsii (*Gutw.*) *West*	V.R.				×		
270. C. Subcucumis *Schmidle* . .	R.	×		×	×	×	×
271. C. subprotumidum *Nordst.* var. Gregorii (*Roy and Biss.*) *West* .	V.R.	×					
272. C. subundulatum *Wille* . .	R.	×	×			×	
273. C. subquadratum *Nordst.* . .	R.	×		×	×		
274. C. subquadrans *W. and G. S. West*	R.	×	×	×	×	×	
275. C. tatricum *Racib.* var. sphaeruliferum *West*	V.R.		×			×	
276. C. trachypleurum *Lund.* var. minus *Racib.*	V.R.	×					
277. C. Thwaitesii *Ralfs* . . .	R.	×				×	
278. C. tenue *Arch.*	V.R.		×		×	×	
279. C. tumidum *Lund.*	V.R.		×				×
280. C. tinctum *Ralfs*	C.	×	×	×	×	×	×
281. C. trilobatum *Reinsch* . .	R.		×				
282. C. undulatum *Corda*	V.R.	×					
283. C. undulatum var. minutum *Wittr.* ($21 \times 18\mu$)	R.						×
284. C. venustum (*Bréb.*) *Arch.* .	R.		×	×	×	×	×
285. C. venustum var. majus *Wittr.* .	V.R.			×			
286. C. viride (*Corda*) *Josh.* . .	V.R.			×		×	
287. C. viride forma minor *West* . .	V.R.	×					
Genus **Xanthidium** Ehrenb. 1837.							
288. X. aculeatum *Ehrenb.* . .	F.	×	×			×	
289. X. antilopaeum (*Bréb.*) *Kütz.* .	F.	×	×		×	×	
290. X. armatum (*Bréb.*) *Rabenh.* .	C.	×	×	×	×	×	×
291. X. armatum var. irregularius *West*	V.R.		×	×		×	
292. X. Brébissonii *Ralfs* . . .	V.R.				×		
293. X. cristatum *Bréb.* . . .	V.R.	×					
294. X. Robinsonianum *Arch.* . .	R.	×	×			×	×
295. X. variable (*Nordst.*) *W. and G. S. West*	V.R.		×				
Genus **Arthrodesmus** Ehrenb. 1838.							
296. A. bifidus *Bréb.* var. latidivergens *West*	R.	×				×	×
297. A. controversus *W. and G. S. West* ($12 \times 12 \times 6\mu$ isth.). . .	F.	×	×	×	×	×	

V.C. = Very Common. C. = Common. F. = Frequent. R. = Rare. V.R. = Very Rare.	Relative frequency in the district described.	Metherall. I	Gidleigh. II	Lydford. III	Haytor. IV	Postbridge. V	Moorpools. VI
298. A. convergens *Ehrenb.*	V.R.					×	
299. A. Incus (*Bréb.*) *Hass.*	C.	×	×	×	×	×	×
300. A. Incus forma minor *W. and G. S. West*	F.	×	×	×	×	×	×
301. A. Incus var. indentatus *W. and G. S. West*	C.	×	×	×	×	×	×
302. A. Incus var. Ralfsii *W. and G. S. West*	V.R.	×				×	
303. A. Incus var. Ralfsii forma latiuscula *West*	V.R.					×	
304. A. Incus var. subquadratus *W. and G. S. West*	V.R.		×				
305. A. Incus var. indentatus forma scrobiculata *W. and G. S. West*	V.R.					×	
306. A. octocornis *Ehrenb.*	F.	×	×		×	×	×
307. A. tenuissimus *Arch.*	V.R.		×			×	
308. A. tenuissimus forma longispina *West*	V.R.		×				
309. A. triangularis *Lagerh.*	V.R.		×				
310. A. triangularis var. inflatus *W. and G. S. West*	V.R.	×					
311. A. triangularis forma triquetra *W. and G. S. West*	R.	×	×	×	×	×	×
Genus **Staurastrum** Meyen, 1829.							
312. S. aculeatum *Men.*	F.	×	×		×	×	×
313. S. alternans *Bréb.*	F.	×	×	×	×	×	
314. S. alternans var. pulchrum *Wille*	V.R.				×		
315. S. apiculatum *Bréb.*	F.	×	×		×	×	×
316. S. asperum *Bréb.*	F.	×	×	×			×
317. S. avicula *Bréb.*	R.				×	×	
318. S. Bieneanum *Rabenh.*	V.R.					×	×
319. S. Bieneanum var. ellipticum *Wille*	R.			×	×	×	
320. S. brevispinum *Bréb.*	F.	×	×	×	×	×	
321. S. brachiatum *Ralfs*	F.	×	×		×	×	×
322. S. Capitulum *Bréb.*	V.R.				×	×	
323. S. controversum *Bréb.*	F.	×	×		×		×
324. S. cristatum *Näg.*	V.R.				×	×	
325. S. cuspidatum *Bréb.*	V.R.		×				
326. S. cyrtocerum *Bréb.*	F.	×	×		×	×	
327. S. dilatatum *Ehrenb.*	F.	×			×	×	
328. S. dilatatum var. hibernicum *W. and G. S. West*	V.R.		×				
329. S. dispar *Bréb.*	F.	×	×	×	×	×	
330. S. Dickeii *Ralfs*	V.R.	×				×	
331. S. dejectum *Bréb.*	V.C.	×	×	×	×	×	×
332. S. ellipticum *West*	V.R.			×			
333. S. furcatum *Ehr.*	F.				×	×	×

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334. S. furcatum var. candianum *Delp.*	V.R.						×
335. S. furcigerum *Bréb.* . . .	F.	×	×	×	×	×	×
336. S. furcigerum var. reductum *W. and G. S. West* . . .	V.R.	×					
337. S. furcigerum forma armigerum *(Nordst.) G. S. West* . .	R.		×				
338. S. furcigerum forma eustephanum *(Nordst.) G. S. West* . .	F.	×	×			×	
339. S. Griffithsianum *(Näg.) Arch.* .	V.R.	×					
340. S. glabrum *(Kütz.) Ralfs* . .	R.	×	×				×
341. S. gracile *Ralfs* . . .	F.	×	×		×	×	
342. S. granulosum *(Ehrenb.) Ralfs* .	R.	×			×	×	
343. S. grande *Bulnh.* var. parvum *West*	V.R.					×	
344. S. hirsutum *Bréb.* . . .	C.	×	×	×	×	×	×
345. S. hystrix *Ralfs* . . .	V.R.	×	×				
346. S. inconspicuum *Nordst.* . .	F.	×	×	×		×	
347. S. inflexum *Bréb.* . . .	V.R.	×				×	
348. S. lanceolatum *Arch.* . .	V.R.		×		×	×	
349. S. laeve *Ralfs*	V.R.		×				
350. S. laevispinum *Biss.* . . .	V.R.						×
351. S. lunatum *Ralfs* . . .	V.R.	×					
352. S. margaritaceum *Meneg.* . .	C.	×	×	×	×	×	×
353. S. O'Mearii *Arch.* . . .	V.R.		×				
354. S. Meriani *Reinsch* . . .	V.R.	×				×	
355. S. monticulosum *Bréb.* . .	V.R.	×	×				
356. S. muricatum *Bréb.* . . .	V.R.					×	
357. S. muticum *Bréb.* . . .	R.		×	×	×	×	
358. S. oligocanthum *Bréb.* . .	V.R.		×				
359. S. orbiculare *Ralfs* var. Ralfsii *W. and G. S. West* . . .	V.C.	×	×	×	×	×	×
360. S. orbiculare var. depressum *Roy and Biss.*	F.	×	×	×	×	×	×
361. S. paradoxum *Meyen* . .	F.		×		×	×	×
362. S. paradoxum var. longipes *Nordst.*	R.	×	×				
363. S. paxilliferum *G. S. West* .	V.R.	×				×	
364. S. pilosellum *W. and G. S. West*	V.R.				×	×	
365. S. pileolatum *Bréb.* . . .	V.R.			×		×	
366. S. polymorphum *Bréb.* . .	F.	×	×		×		×
367. S. punctulatum *Bréb.* . .	V.C.	×	×	×	×	×	×
368. S. punctulatum var. subproductum *W. and G. S. West* .	V.R.						×
369. S. punctulatum var. Kjellmanni *Wille*	C.	×	×	×	×	×	×
370. S. punctulatum var. pygmaeum *(Bréb.) W. and G. S. West* .	R.				×	×	
371. S. punctulatum var. striatum *W. and G. S. West* . . .	V.R.	×			×		
372. S. punctulatum forma minor *W. and G. S. West* (20–22 $\mu\times$15–17μ)	R.		×		×		

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373. S. proboscideum *Bréb.*	V.R.	×	×				
374. S. Pringsheimii *Reinsch*		×	×			×	
375. S. pterospermum *Lund.*	V.R.					×	
376. S. Reinschii *Roy*	F.	×	×	×	×	×	×
377. S. retusum *Turn.* var. boreale *W. and G. S. West*	V.R.			×			×
378. S. saxonicum *Reinsch*	V.R.		×				
379. S. sexcostatum *Bréb.*	F.	×	×		×	×	×
380. S. striolatum (*Näg.*) *Arch.*	R.	×	×			×	
381. S. subcruciatum *Cooke and Wills*	V.R.		×			×	
382. S. suborbiculare *W. and G. S. West*	R.	×	×		×		
383. S. teliferum *Ralfs*	C.	×	×	×	×	×	
384. S. tricorne *Bréb.*	F.	×	×	×	×	×	×
385. S. tumidum *Bréb.*	F.	×	×		×	×	
386. S. turgescens *De Not.*	F.	×	×	×		×	
387. S. vestitum *Ralfs*	V.R.	×					
Genus **Cosmocladium** Bréb. 1856.							
388. C. constrictum (*Arch.*) *Josh.*	V.R.					×	
Genus **Sphaerozosma** Corda, 1835.							
389. S. excavatum *Ralfs*	F.	×	×	×	×	×	
390. S. filiforme (*Ehrb.*) *Rabh.*	V.R.				×	×	
391. S. pygmaeum *Rabh.*	F.	×	×		×	×	×
392. S. vertebratum *Ralfs*	F.	×		×	×		
393. S. pulchellum (*Archer*) *Rabh.*	R.	×					
Genus **Hyalotheca** Ehrenb. 1840.							
394. H. dissiliens (*Smith*) *Ralfs*	V.C.	×	×	×	×	×	×
395. H. dissiliens var. minor (*Mert.*) *Ralfs*	F.	×	×	×	×	×	×
396. H. mucosa (*Mert.*) *Ralfs*	F.	×	×	×	×	×	×
Genus **Desmidium** Agardh, 1824.							
397. D. Swartzii (*Ag.*) *Ralfs*	V.R.	×				×	
398. D. cylindricum *Grev.*	V.R.					×	
Genus **Gymnozyga** Ehrenb. 1840.							
399. G. moniliformis *Ehrenb.*	F.	×	×	×	×	×	

TWO NEW SPECIES OF HYDRACARINA OR WATER-MITES

Dartia Harrisi gen. et sp. nov. and **Eylais Wilsoni** sp. nov.

By Chas. D. Soar, F.L.S., F.R.M.S.

(*Read March 27th,* 1917.)

Plates 20, 21.

While collecting Desmids on Dartmoor in August 1916, Mr. G. T. Harris found several specimens of water-mites which he submitted to me for identification. Amongst the specimens were some from Broad Down Bog, near Postbridge, which proved of more than common interest. These exhibited the following noteworthy features: modification of second pair of legs, absence of claws on fourth pair and swimming hairs entirely wanting. There are several genera of Hydracarina in which the claws above mentioned are absent, but they all possess the swimming hairs. For the reception of this water-mite it is proposed to create a new genus, and as the specimens were found in the neighbourhood of the River Dart the name Dartia is suggested. The only species of this genus at present known is named after Mr. Harris—*Dartia Harrisi.*

Dartia gen. nov.

The body is oval in outline; skin soft. The eyes wide apart near margin of body. Legs without swimming hairs; the fourth pair of legs without claws. Epimera in four groups. Genital area similar to that of Lebertia, but instead of the usual three acetabula on each side of the genital cleft, there are four. The palpi each have a long, stiff bristle on the flexor edge of the second segment.

Dartia Harrisi sp. nov.

Plate 20.

Specific Characters.—Body : about 0·74 mm. in length by about 0·71 mm. in breadth; dorso-ventral dimensions 0·36 mm. A slightly rounded oval in outline. The skin is soft, apparently finely ridged, the ridges wide apart. The anterior part of the dorsum has four longitudinal rows of gland-pores, each surrounded by a strong chitinous ring and standing out prominently like tubercles; the posterior pair of the two inner rows lying near centre of dorsum. Slightly posterior to these are a pair of small plates and, a little wide apart, a pair of gland-pores similar to the others. In centre of posterior part of dorsum is an ovate porate chitinous plate with the apex directed posteriorly, and on each side a gland-pore with strong chitinous ring. On the edge of the body four or five similar pores occur on each side (Pl. 20, fig. 1). The body colour is bright red, but all the chitinous parts are a slaty blue.

Palpi.—Length about 0·33 mm. Second segment, proximal half of extensor surface with two small spines, distal half with three small spines, directed towards inner edge; flexor surface nearly straight with one moderately long straight bristle pointing obliquely forwards. Third segment of nearly equal width throughout, flexor surface concave, extensor surface with one small spine placed midway and a short one near the distal end; a moderately long bristle is placed on the outer edge of the distal end of the flexor surface; anterior portion of segment hyaline, permitting the base of the fourth segment to be seen at the articulation. Fourth segment about half the diameter of the third, flexor surface with a tubercle midway and a long curving hair springing therefrom; proximal half nearly straight, the distal half concave, with three or four short fine hairs arising from minute papillae; the margin at the distal end has two straight hairs, and another on the extensor surface; end of segment blunt. Fifth segment compressed laterally, short, curved, ending in four or five claw-like processes, (Pl. 20, fig. 3); colour a slaty blue, extremity with a tinge of orange.

Epimera.—First and second pairs very much like those of *Limnesia maculata*, but with posterior margin rather more

irregular. Third pair lying well up against the second pair and fused with the fourth pair with a very indistinct line of demarcation; inner angle rounded, projecting well forward, the inner margin weakly indented, extending obliquely outwards to the rounded posterior margin (Pl. 20, fig. 2).

Capitulum without rostrum, slightly cone-shaped anteriorly, sides almost straight, parallel, posterior margin straight; mandible 0·27 mm. in length, distal end weakly sinuate, the edge turned towards the body distinctly serrate, proximal end clavate, the intermediate portion moderately arched.

Legs.—First pair of legs about 0·53 mm. in length; second pair about 0·55 mm.; third pair, 0·60 mm.; fourth pair, 0·78 mm. The first segment of the first leg is very wide and acetabular; second segment with proximal flexor surface slightly arched and with an oblique chitinous fold; third, fourth and fifth segments with proximal end contracted; sixth segment apparently devoid of hairs, claws very small and slender, distal end thicker than proximal. The leg is rather sparingly supplied with spines and bristles. First segment of second pair similar to that of first pair but larger and broader; the fifth segment is rather more modified than usual, the proximal half of the flexor surface bulging out very considerably, while the distal half is concave. Sixth segment, distal end wider than proximal; a rather conspicuous feature here is the proximal end of this segment, which is bent nearly at right angles where it articulates with the distal end of the fifth segment (Pl. 20, fig. 5); the claws are similar to those of the first pair of legs, while the hairs, as in the first pair, are not very numerous. Third pair of legs very like the first pair, but each segment longer; the claws are also small and slender. Fourth pair: this pair requires more detailed description. The extensor surface of the first segment has two short spines on the distal half and another, longer, on the distal margin; the proximal portion of the second segment is very much contracted, extensor surface with two short spines and flexor surface with two moderately long ones at the distal margin; the distal end of third segment is much stouter than the proximal, extensor surface has five spines and a shorter and broader one at the distal end, the distal margin with four broad, moderately long ones: fourth segment, extensor surface with three pairs of spines, flexor surface with one very short spine in

proximal half, and three in distal half, distal end with three pectinate spines; fifth segment, extensor surface with two short spines and three on distal margin, the flexor surface has about five spines; sixth segment, more slender than any of the other segments, flexor surface with three or four small spines, without claws, but with a long, fine terminal bristle at the base of which there are one or two very short hairs.

The genital area lies for about half its length between the fourth pair of epimera, at each end is a strong, curved chitinous bridge for muscle attachments. There are two pairs of acetabula on each side of the genital cleft, protected by a porate valve or flap which is probably fringed with short hairs. The acetabula are oval or elliptical in outline, each pair being united by means of a chitinous band; the proximal and distal margins are rounded and the ends pointing inwards, tapered. This number of acetabula in the genital area is rather uncommon, the more usual number being three on each side of the cleft. Sex unknown.

I wish here to acknowledge my indebtedness to Mr. William Williamson, F.R.S.E., for his valuable assistance in determining the characters of this water-mite.

Towards the end of May in the year 1914, I received from Mr. J. Wilson, F.R.M.S., a small collection of water-mites taken in the neighbourhood of Staines. Amongst them were four specimens of the same species referable to the genus Eylais, but the name of which I was unable to determine. The most important characteristic for purposes of identification in the species of this genus is the eye area. This I was quite unable to obtain a good view of while the mite was alive, so I killed the four specimens and left them in the glycerine solution sufficiently long to remove the colour from the integument. When this was nearly complete, I was then able to see the eye-capsule quite distinctly and was surprised not to find any actual plate or connection between the eyes, a feature which is found, so far as the literature at present available shows, in all other known species of this genus, now numbering over a hundred. I dissected the area surrounding the eyes and made a camera drawing of this in the case of three of the specimens; the fourth specimen

was spoiled. The dissections were then mounted, two in glycerine jelly and one in Canada balsam. On examination of the mounted material it was seen, however, that the results of the first examination were quite correct:—each eye-capsule standing alone or separate on the body skin of the mite. There was no visible connection, neither bridge nor chitinous ridge such as has always been seen in the case of all species of Eylais previously examined. In these circumstances I feel bound to conclude that the water-mites Mr. Wilson sent me are at present undescribed, and I propose therefore to do so, giving this nova of the genus Eylais the name *Wilsoni*.

Eylais Wilsoni sp. nov.

Plate 21.

The four specimens received were females; about 3·70 mm. in length, rather a large size. Of the usual shape and colour and in all respects, so far as external characters are concerned, resembling when alive all other species of the genus. The actual measurements of the body are about the same as those of the type species *E. extendens* Müll., which it resembles except in the eye area, where a difference is found. In *Eylais extendens* Müll. the eye-capsules are connected by a bridge of chitin, the anterior portion of which is about level with the front edge of the capsule; the posterior margin is also deeply incurved. In *E. Wilsoni*, however, there is no connection whatever, the capsules being isolated on the integument. The figures (Pl. 21, fig. 1) show the position they occupy in relation to each other. The width across the outside of the capsule is about 0·48 mm., the length about 0·28 mm. The anterior lens is set a little way in from the anterior margin, and the posterior lens occupies about the same position as in the case of the type species. Each capsule is more or less surrounded by a chitinous projection from which on the anterior inner margin arise the usual bristles.

The capitulum (Pl. 21, fig. 2) including the pharynx is about 1 mm. in length, by about 0·74 mm. in breadth; the inside of the oral area is about 0·12 mm. The air-sacs reach nearly to the posterior margin of the pharynx; the anterior lateral processes are long and wide; the pharynx projects beyond the posterior

lateral process about 0·16 mm. The air-sacs are broad and straight when viewed from the front, but curve outwards towards the outer margin of the pharynx. The figure (fig. 2) has been drawn from a mounted specimen, so it is quite possible it appears flatter than when in a living condition. The palpi are very like those of the type species except that they appear to be more fully provided with hairs (figs. 3 and 4). The segments (1–5) measure as follows: 0·14 mm., 0·28 mm., 0·28 mm., 0·60 mm., 0·26 mm. These measurements are taken on the outside, extensor margin. The surface of the skin is strongly marked.

Descriptions of Plates.

Plate 20.

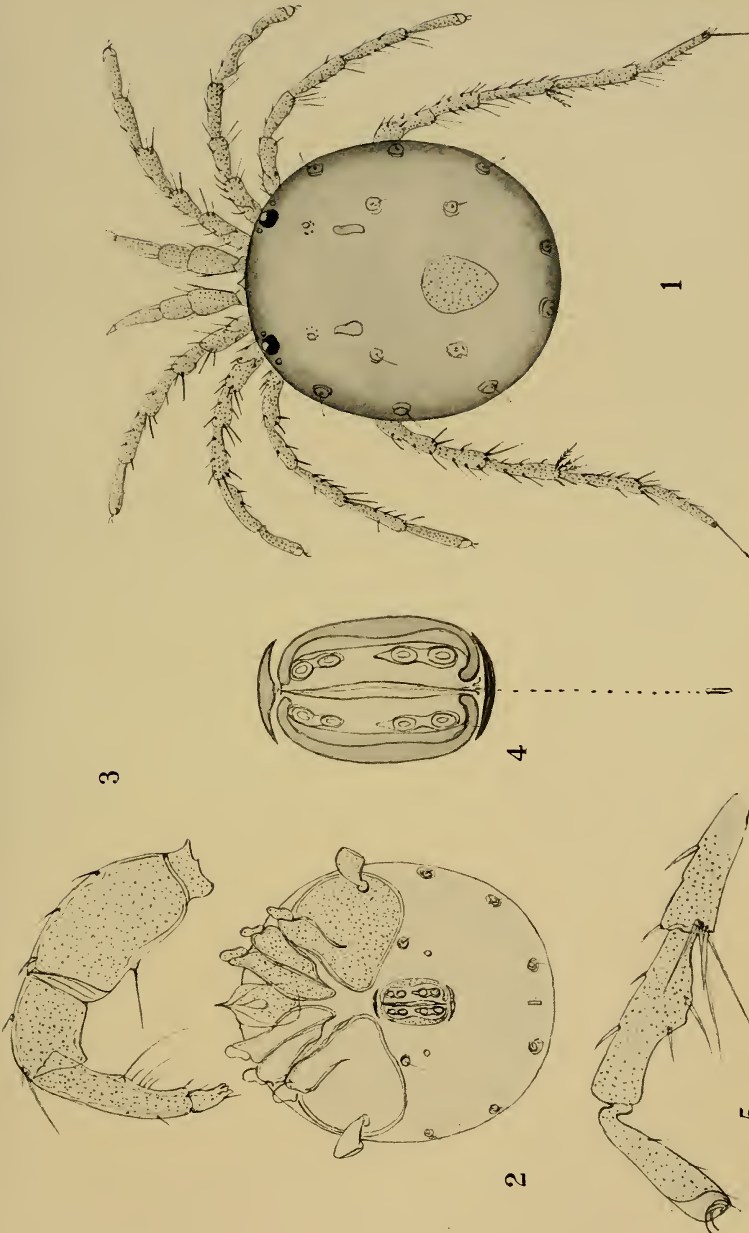
Dartia Harrisi gen. et sp. nov.

1. Dorsal surface.
2. Ventral surface, showing epimera and genital area.
3. Inner surface of right palp.
4. Genital area, showing relative position of anus.
5. Second leg; articulation of fifth and sixth segments.

Plate 21.

Eylais Wilsoni sp. nov.

1. The eye and eye-capsules.
2. Capitulum.
3. Inner surface of right palp.
4. End of palp.



C. D. Soar, delin. ad nat.

Dartia Harrisi *gen. et sp. nov.*

C. D. Soar, delin. ad nat.

Eylais Wilsoni *sp. nov.*

NOTICES OF BOOKS.

Histology of Medicinal Plants. By William Mansfield, A.M., Phar.D. xii + 305 pages. 9 × 6 inches. 54 text figures and 127 plates in the text. (New York: John Wiley & Sons. [London: Chapman & Hall.] 1916. Price 12*s*. 6*d*. net.)

This book is intended to provide a practical scientific course in vegetable histology for the use of teachers and students. Those colleges in which special attention is paid to the botany of medicinal plants and practical work is carried out in the examination and diagnosis of powdered drugs of vegetable origin will find it an admirable example of method. Part I contains details of the microscope and instruction is given in the use of the instrument as well as in the microscopical technique required in the preparation and mounting of the material to be examined. Part II deals with the general histology of tissues, cells and cell contents, and here special attention has been paid to cell-inclusions such as starch grains, aleurone grains and crystals, which are often of great use in the diagnosis of fragmentary material. Part III is devoted to the special histology of roots, rhizomes, stems, barks, woods, flowers, fruits and seeds, the examples figured and described being from plants officinal in the United States. This part is very fully illustrated by 127 plates in the text from drawings made by the author from actual specimens. These drawings, ranging as they do over a very wide series of medicinal plants, give the book a very distinctive character. The author claims that the new classification of plant fibres and hairs which is introduced into Part II will clear up much of the confusion that students have experienced when studying these structures. The book is essentially practical, but its use in Great Britain must be limited by the fact that the material illustrated is chiefly drawn from plants rarely coming under the notice of the student of pharmacology.

CAMBRIDGE BOTANICAL HANDBOOKS: Algae, Vol. I. Myxophyceae, Peridinieae, Bacillarieae, Chlorophyceae, together with a brief summary of the occurrence and distribution of freshwater Algae. By Prof. G. L. West, M.A., D.Sc., A.R.C.S., F.L.S., viii + 475 pages. $7 \times 10\frac{1}{4}$ inches. 271 text figures. (Cambridge: at the University Press, 1916. Price 25*s*. net.)

The CAMBRIDGE BOTANICAL HANDBOOKS have been designed to provide the student who desires to pursue his studies beyond the limits of the general textbook with a series of volumes by specialists on different groups of the vegetable kingdom. The first of the series to appear is the above work dealing with certain groups of the Algae; other volumes of the series in an advanced state of preparation are on Lichens, by Miss Lorrain Smith, Fungi, by Dr. Helen Gwynne-Vaughan, and the Gnetales, by Professor Pearson. Each volume will review from a broad standpoint the results of recent research, more especially as they affect the actual problems of evolution presented by the various classes of plants with which it deals.

When Professor West's *Treatise on British Freshwater Algae* was published in the CAMBRIDGE BIOLOGICAL SERIES some twelve years ago, the student of this group of plants felt that now indeed he had a guide through the labyrinth of conflicting views and nomenclature that obscured the subject. And the worker who admired the lucidity with which the complex details were presented in that volume and its orderly arrangement will not be disappointed on turning to this one. Since the publication of the "Treatise" very considerable advances have been made in our knowledge of many groups of Algae, and it is now proposed to replace it by two works of which the volume under review is one; the other now in course of preparation will be a complete systematic account with illustrations of the freshwater Algae (with the exception of Desmids and Diatoms) which are known to occur in the British Islands. The volume now published contains a biological account of all the Algae included in Myxophyceae, Peridinieae, Bacillarieae, Chlorophyceae, both freshwater and marine, and therefore from a biological point of view more than covers the Algae dealt with in the earlier work.

One turns very naturally perhaps to the chapter dealing with

the Peridinieae of which group no very comprehensive account has hitherto appeared in any English textbook. It may even be a surprise to some to find these interesting organisms dealt with at all in a botanical treatise. Yet next to the Diatoms they are the most important "producers" of organic substance in the sea. Professor West claims them as true vegetable organisms with holophytic nutrition. Indeed the distinction between animal and vegetable organisms is so clearly stated in this connection that we venture to quote it:

"The only sound basis for the discrimination between animal and vegetable organisms is nutrition. It must be borne in mind that all protoplasts, be they animal or vegetable, require practically the same classes of food-substances, and, moreover, they assimilate them in precisely the same way. The vegetable protoplast has, however, acquired the power of constructing its own organic food-substances. In contrast, therefore, to the animal protoplast, which requires its organic food presented to it in an available and assimilable form, the vegetable protoplast is capable of performing the preliminary synthetic work of constructing complex food-substances from raw materials. This constructive work is carried out in the normal plant by means of chromatophores, and is dependent upon light, and hence the photosynthetic activity of the typical vegetable organism is its fundamental characteristic. The raw materials enter the protoplast in a state of solution, and the elaborated materials which are the final products of photosynthetic activity are from the beginning *within the protoplast* ready for immediate assimilation whenever the action of enzymes renders them thus available. Such nutrition is *holophytic*.

"The animal organism, on the other hand, has to take in *from the outside* elaborated materials insoluble in water, and for the necessary enzyme-action to work efficiently during the assimilation of these substances they must be confined within a space which is more or less limited. Consequently, the normal animal organism has had perforce to adopt a method of ingestion of solid food-substances. This type of nutrition is *holozoic*."

The author has devoted most of his investigations to the study of the Green Algae; the greater part of this work deals with that group and embodies much original research. In a large group containing so many diverse types (the number of known species is probably 5,000) a comprehensive treatment such as was adopted for the Myxophyceae or Peridinieae might have led to confusion in the mind of the student. Hence we have the orders of the Chlorophyceae treated in greater detail. The final

chapter is devoted to the ecology of the freshwater Algae; as this subject is, however, still in its infancy any very satisfactory account with our present knowledge is impossible; but the results which are given, based largely on the author's wide experience during twenty years, are very interesting indeed, and this chapter will well repay careful study. In fact, there is here almost an open field for the student to increase our knowledge.

There are bibliographies to each group of Algae and an excellent index; the illustrations in the text comprise 1,284 lettered or numbered figures.

We congratulate the author on the completion of this valuable contribution to botanical literature and the Syndics of the University Press on the appearance of the first of the "Handbooks."

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 519th Ordinary Meeting of the Club, held on October 24th, 1916, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on June 27th were read and confirmed.

Messrs. Edward B. Stringer and Charles W. Penn were balloted for and duly elected members of the Club ; eight names nominated for election were read by the Hon. Secretary, who stated that the Club was to be congratulated upon the number of new members it was obtaining, notwithstanding the war.

The Hon. Secretary informed the meeting that Mr. J. M. Offord, F.R.M.S., had presented the Club with six slides of various microscopic writings and figures, the work of the late Dr. Farrant. Mr. Offord had also brought a micro-slide portrait of Professor Quekett, formerly President of the Royal Microscopical Society, taken by Dr. Farrants, which was presented by Mr. Sidney H. Tonks. A hearty vote of thanks was passed by the meeting to Mr. Offord.

Mr. David Bryce then read the second (and final) part of a paper, "On the Bdelloid Rotifera of South Africa," by Mr. W. Milne, M.A., B.Sc. In introducing the paper, Mr. Bryce said all would regret that Mr. Milne was unable to be present. It would be remembered that on the occasion of his reading the first part he had had an exceedingly trying experience in his journey from Aberdeen. In consequence of the severe blizzard (March 28th), the train had arrived in London nearly twelve hours late, and Mr. Milne had no opportunity for rest, and had scarcely time for a necessary meal before reading his paper to the meeting.

Mr. Bryce said that the paper contains descriptions of nineteen new species, four new varieties, and one new genus. It is naturally of considerable length, and the descriptions, consisting mainly of technical particulars, are not suitable for reading in full detail.

He proposed, therefore, to mention briefly what seemed to be the most striking characteristics of the various forms.

Mr. Bryce stated that he had only seen one of the species or varieties now described, but he was pleased to note that since his return to Scotland Mr. Milne had already found in Aberdeenshire three of the species which he had previously discovered in Cape Colony. Mr. Bryce then briefly described various species of the genera—Macrotrachela, Habrotrocha, Mniobia, Scepanotrocha, Pleuretra, Otostephanos and Adineta.

In conclusion, Mr. Bryce stated that Mr. Milne hoped to furnish as an appendix to this paper a list of all the Bdelloida he had observed in South Africa. When this is prepared and the results collated with the late James Murray's list of the species identified and discovered by him in the same region, it may be expected that the combined record of South African Bdelloida will be much longer than can yet be shown for any other country in the world, Great Britain alone excepted.

The President, in commenting on the paper, said they were all greatly indebted to Mr. Bryce for the care and pains he had taken in bringing it before them. He (the President) had had the advantage of seeing the plates illustrating it, which were very beautiful and added greatly to the interest. He thought, however, it would be more convenient if the measurements of microscopic objects were given in the metric system, which has now superseded the statement of size in fractions of the English inch.

A considerable amount of discussion ensued on this subject. Mr. Bryce said he was quite in accord with the President in the matter, and believed he was the first in this country to state the measurement of Rotifera in *microns*.

The Chairman proposed a hearty vote of thanks to the author, and to Mr. Bryce for reading the paper, which was unanimously agreed to by all present.

At the 520th Ordinary Meeting of the Club, held on November 28th, 1916, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on October 24th, 1916, were read and confirmed.

Messrs. Joseph Fletcher, B.D., B.A., Charles Nicholson, Leonard N. Hensman, C. W. Bushell, the Hon. Francis W. S.

McLaren, J. Gadsden, John Martin and Arthur S. Hill were balloted for and duly elected members of the Club ; five nomination forms for membership were read.

A donation to the Club from the collection of the late Mr. R. T. Lewis of a box of slides of Coccidae from Mr. J.M. Offord, F.R.M.S., was announced. These had been mounted by Mr. Maskell, of New Zealand, who was an authority on the group. The President said when he was in New Zealand Mr. Maskell was alive, and these appear to be his own mountings, and are probably type slides. A hearty vote of thanks was accorded to the donor.

The President then requested Mr. D. J. Scourfield, F.Z.S., to take the chair while he gave an account of "Gelatinous Sponge Spicules." The address was illustrated by lantern-slides projected upon the screen. The President referred to the old saying that "if you keep a thing for seven years you will find a use for it." In the present instance he thought that the time was too short, and the specimens he proposed to talk about had been kept for more than three times seven years. When in Australia some twenty-five years ago he had a large collection of material, and had to go through it rapidly and compile a short catalogue. Amongst other things, he found a sponge which contained peculiar objects that looked like spicules and yet did not. They were kidney-shaped, and were not bright, like ordinary spicules. He was unable to identify them and laid them aside. Recently, whilst working on sponges from the Indian Ocean, he came across some which contained similar bodies. He had forgotten the previous discovery in Australia, but on looking through his notes he found his original sketch. An old slide containing a rough section had not been thrown away, and he was able to unearth it. He took the section, which consisted almost entirely of sand, unmounted it, and then investigated it by micro-chemical methods. These enigmatical bodies were shown to be spicules of a very unusual character. They consisted of hydrated silica, although not identical in character with the usual siliceous spicules. They were submitted to various tests, including immersion in caustic potash and in hydrochloric acid, staining and examination by means of the polariscope. It was found that they had the peculiarity of swelling up when placed in water, which is a characteristic not possessed by ordinary siliceous spicules. It was suggested that in the living sponge they must occur as a jelly, but

in a mounting they become dehydrated and shrivelled. It was remarkable that these specimens, which had been in balsam for twenty years, still retained this capacity for absorbing water; those from the Indian Ocean behaved in a similar manner. The conclusion was arrived at that they consisted of silica in a colloidal state and contained a larger proportion of water than usual. The material was well preserved. There was no difficulty in identifying the mother-cells by which the spicules were formed. These are known as *scleroblasts*. They have a small nucleus suspended in the centre with granules close to the cell-wall. The illustrations showed the gelatinous spicules, or colloscleres, developing on the exterior of the mother-cells, enclosed in vesicles in the ground-substance of the sponge. A detailed account of this discovery was published in the Proceedings of the Royal Society for 1916, the new genus Collosclerophora being proposed for the Australian species in which colloscleres occur.

The Chairman said we had had a very remarkable and interesting communication from the President. The statement about the preservation of drawings and material ought to be taken to heart by everyone, as it is only by piecing together observations spread over a series of years that many can arrive at the true results of their work.

Messrs. Blood, Hilton and Dr. Rudd Leeson took part in a discussion. At the Chairman's suggestion, a hearty vote of thanks was accorded to the President for his interesting address, who, after replying, resumed the chair.

Mr. N. E. Brown exhibited under a binocular microscope the very beautiful white seeds of *Anacampseros rubens*. He remarked that really white seeds are very uncommon ; probably, with the exception of a few of the beans, those present had very seldom come across any. Plants of the genus Anacampseros came from the drier parts of South Africa. There are two groups—one has evident leaves, in the axils of which there is a tuft of hairs. These hairs in some species are small and very much shorter than the leaves; in others they are more numerous and larger, and the leaves, which are small, are partly concealed by the hairs. In the other group the leaves are completely hidden by scales. Examples of the latter group had been cultivated in a greenhouse for many years in this country without it having been discovered that they flowered at all. However, it was observed at last that

a seed capsule was thrusting through the top of the scales, which at once gave evidence that the plant had been in flower. It was then seen that the cause of the belief that the plants never flowered was owing to the fact that, in addition to the inconspicuous nature of the flower, it only appeared during the evening or night and endured but for a few hours. A number of the seeds of *A. rubens* were brought for distribution among the members. It was stated that in Rhodesia a decoction of the plants was used as an intoxicant by the natives to such an extent as to require Government intervention. Various specimens of the plants, both dry and fresh, and seed capsules were exhibited. An interesting discussion took place, and, in reply to questions, Mr. Brown said that the plants were xerophytic, and that probably cleistogamous flowers occurred among them.

Mr. J. Richardson, F.R.M.S., exhibited on one of the tables a series of very beautiful photomicrographs of the genus Triceratium among the Diatomaceae. The photos represented about 120 species, and were arranged on a number of card sheets, which enabled them to be examined and the various forms compared with great facility. They were taken by Mr. Thomas Castle, of Heckmondwyke, and were greatly admired by those present.

Mr. S. C. Akehurst, F.R.M.S., exhibited and described a tank and weed-holder for pond life to be used with low-power water-immersion objectives. The tank is of metal, and is fitted into a slide—fluid capacity 1½ oz. It can be adapted for use in conjunction with the base of a Rousselet live-box. It should be filled with pond water to a suitable height and the immersion-objective plunged into the water. Most free-swimming organisms being phototropic, they soon enter the field, and a fairly rapid examination can be made. For fixed forms on pond weed a holder with universal movements has been provided. The apparatus would be useful for searching large quantities of water for Plankton forms.

Under a microscope on the table a slide of *Pleodorina illinoisensis* was exhibited. This is an organism belonging to the Volvoceae, and Mr. Scourfield, in calling attention to it, shortly described the group, referring to the various members, Gonium, Pandorina, Eudorina, Pleodorina, Platydorina and Volvox. He explained that Pleodorina, which is found in many parts of the United States of America, and has recently been taken in England,

consisted of a subspherical mucilaginous envelope with spherical cells in it, which closely resemble those of Eudorina. They were remarkable because some of them (in the species shown, four at the anterior end) are smaller and simply vegetative in character, while the remainder are larger and reproductive; in Eudorina and its closer allies all are reproductive. Volvox and its method of movement were also referred to and described.

The meeting closed with a hearty vote of thanks to the authors of these various communications.

At the 521st Ordinary Meeting of the Club, held on January 23rd, 1917, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on November 28th, 1916, were read and confirmed.

Messrs. John Kiell, Albert A. Stow, J. W. Flower, A.M.I.E.E., Charles S. Burt and Ronald Winter were balloted for and duly elected members of the Club; six nomination forms for election were read by the Hon. Secretary.

A small wax medallion portrait of Dr. Quekett, after whom the Club is named—a gift from a member—was exhibited. The President read a list of the names of those who had been nominated by the committee as officers for the year, and the members present made nominations to fill the vacancies on the committee.

At the request of the President, Mr. David Bryce then read a paper—"On the Collecting of Bdelloid and other Rotifera." He said: "Since the first discovery of Rotifera by the illustrious Antony van Leeuwenhoek, rather more than 200 years ago, these most interesting creatures have captured the attention and admiration of generations of microscopists, who have willingly devoted much labour to their investigation. They have found in them a remarkable diversity of form, allied with the most complicated and specialised organs, an astounding variety and activity of movement, and an infinity of devices for the capture of their food." Apparently the first English naturalist to publish any original observations on the Rotifera was Henry Baker, whose name is familiar as being allotted to the well-known *Brachionus Bakeri*. After Baker's time there does not appear to have been any original work done by English observers till the middle of the nineteenth century. Pritchard's *Natural History of the Animalcules*, published in 1834, and the same author's *History of*

the Infusoria, 1842, were little more than compilations, the latter especially being largely based on Ehrenberg's *magnum opus*. There was a short paper by Brightwell in 1848, followed by Dalrymple and by Dobie in 1849, and in 1850 by Gosse. In 1886 Hudson and Gosse published their epoch-making Monograph *The Rotifera or Wheel Animalcules*. This, with the long and exceedingly useful lists since compiled by Mr. C. F. Rousselet, and published from time to time in the *Journal of the Royal Microscopical Society*, has given the fascinating study of the Rotifera a great impetus in recent years.

Mr. Bryce then described the various habitats of the Bdelloid Rotifera, to which he had devoted the greater part of his attention for many years. The method of dealing with the material obtained, in order to free the rotifers from foreign matter, was described, and the necessary apparatus suitable for collecting the free-swimming forms and those that are found on the bottom of the pools they frequent.

The apparatus used by Mr. Bryce in collecting and examining the specimens were exhibited on the table, and were explained by him after the meeting. Several members asked questions on different points, to which Mr. Bryce replied; and the President, after remarking on the interest and usefulness of the paper, proposed a vote of thanks to its author, which was given heartily by acclamation.

At the 522nd Ordinary Meeting, which was also the 51st Annual Meeting, held on February 27th, 1917, the President, Prof. Arthur Dendy, D.Sc., F.R.S., in the chair, the minutes of the meeting held on January 23rd were read and confirmed.

Messrs. Alfred B. Rendle, D.Sc., F.R.S., Humphrey G. Billinghurst, Frederick W. Woodman, Ambrose H. John, John Wigelsworth and the Rev. Thomas Read were balloted for and duly elected members of the Club.

The special business of an annual meeting was then proceeded with. The President asked Messrs. N. E. Brown and M. Blood to act as scrutineers, and the ballot was taken for the election of officers for the ensuing year, and to make good the vacancies on the committee caused by the yearly retirement. The result was announced later, the officers as nominated being elected, and four members selected to complete the committee. The Hon. Secre-

tary read the annual report. This was considered very satisfactory. There was a small increase in the membership, the resignations had been but few, though the loss by death had been somewhat more than usual, while the number elected was greater than in the previous year. The attendance at the meetings was good, and there was a satisfactory list of communications and exhibits. The excursions had been well attended. The librarian reported that the number of books borrowed from the library showed no diminution. The curator reported that a large number of valuable micro-slides had been added to the Cabinet, which now contained over 8,000 specimens. The treasurer's accounts and balance-sheet showed that though the finances were somewhat affected by the prevailing difficulties, they were in a perfectly sound condition. The adoption of the reports and balance-sheet was duly moved and carried.

Prof. Dendy then gave his presidential address. The title was "The Chessman Spicule of the genus Latrunculia; a study in the origin of Specific Characters." He said: "It is very well known that there are certain types of tetraxonid microscleres in which the spicule consists of an elongated, rod-like axis with whorls of outgrowths upon it. As a result of a study of some novel varieties of this type it occurred to me that the position of these whorls might correspond with that of the nodes in a vibrating rod, and that thus the form of the spicule might be largely determined by a well-known physical cause, the deposition of silica taking place chiefly where the rod was in a state of rest. The stream of water flowing through the canal system of the sponge seems to afford a sufficient explanation of such vibration, for the spicules are embedded in the very soft, gelatinous mesogloea in the immediate neighbourhood of the canals. I was led to make a somewhat elaborate study of the so-called 'chessman' spicule in two species of the genus Latrunculia, and the development of these proved to be extraordinarily interesting. A good deal has been written on the development of sponge spicules, and some of the published accounts appear to be very contradictory. It would seem that this development is by no means so simple an affair as is often supposed, but is in reality a very complex process, the course of which is determined partly by physical and partly by what may be called biological factors."

The two species, *Latrunculia bocagei* and *L. apicalis*, were ob-

tained by the Challenger expedition at Kerguelen, and the adult form of the curious "chessman" spicules was described in the report by Mr. Ridley and Prof. Dendy. Recently Prof. Dendy, when examining a large number of stained sections which had been preserved, found an almost perfect series of developmental stages. He suggested the name discorhabds for these spicules. The fully-grown discorhabd of *L. bocagei* is about 0·07 mm. in length or height, and really bears considerable resemblance to a chessman.

With the aid of diagrams the process of the formation of the "chessman" spicules of Latrunculia was then described in detail. It was pointed out that development was not identical in the two species, and that certain well-marked differences were of great interest from the point of view of the vibratory theory. Attention was called to the fact that while the spicule of *L. bocagei* terminates with a structure resembling a crown, that of *L. apicalis* has a slender projection at its apex; this projection is really the upper part of the protorhabd, the growth and elongation of which continues after the deposition of silica has commenced upon the shaft.

The President concluded by saying that his observations seemed "to justify the statement that the development of a siliceous sponge spicule is a far more complex process than is usually supposed, and that the course of events is determined by a combination of physical and biological factors. The result appears to be primarily of a non-adaptive character, and in many cases the form of the spicule seems to remain entirely without significance from the utilitarian point of view. Should they happen to be useful for some particular purpose, however, the sponge is not slow to make use of them, and in some unknown way arranges them in the most suitable manner." A useful form might also be fostered and improved under the influence of natural selection, although that can hardly be supposed to be responsible for the minute differences in the form of the spicules in the species under consideration.

"In short, I think we may conclude that the facts which I have submitted afford evidence in favour of the view that the characters by which one species is distinguished from another are usually of little or no importance to their possessor in the struggle for existence, while adaptations are usually shared by many different species."

Mr. D. J. Scourfield, in proposing a vote of thanks to the President for his interesting and valuable address, said he would like to express the great indebtedness the members felt for what Prof. Dendy had done, as President, for the Club in recent years. It had been a trying time, and he thought that often at great inconvenience to himself the President had attended their meetings. Everyone would feel particularly gratified that he had been so kind as to consent to become one of their vice-presidents. He had so interested them on the subject of sponges that there was no question whatever that all thoroughly enjoyed hearing him, the various addresses on the subject being especially appreciated. Mr. Scourfield then requested the President to allow the address he had given that evening to be printed in the *Journal.*

Mr. A. E. Hilton said he should like to second the proposal. Mr. Scourfield had expressed on behalf of the members their sense of indebtedness to Prof. Dendy for the way he had acted as President for the past five years, a record length of presidentship in the Quekett Club. During the whole of the time he had devoted himself with the utmost assiduity to the interests of them all, and had given them a number of most interesting and suggestive lectures.

The vote of thanks having been carried with acclamation, the President in reply said he was grateful for the kind way they had spoken of him. It had always been a great pleasure to be associated with the Club. He gave with pleasure his consent that his paper should be printed in the *Journal.*

A vote of thanks to the auditors and scrutineers was proposed and carried unanimously, a similar compliment being paid to the officers and committee for their work on behalf of the Club during the year. To this the Hon. Treasurer suitably replied.

The result of the ballot for the election of officers for the ensuing year was as follows:

For President . .	A. B. RENDLE, D.Sc., F.R.S.
For Four Vice-Presidents. .	PROF. ARTHUR DENDY, D.Sc., F.R.S. C. F. ROUSSELET, F.R.M.S. D. J. SCOURFIELD, F.Z.S., F.R.M.S. DAVID BRYCE.
For Treasurer . .	FREDERICK J. PERKS.

For Secretary . . James Burton.
,, *Foreign Secretary* C. F. Rousselet, F.R.M.S.
,, *Librarian* . . S. C. Akehurst, F.R.M.S.
,, *Curator*. . . C. J. Sidwell, F.R.M.S.
,, *Editor* . . . A. W. Sheppard, F.Z.S., F.R.M.S.

For Four Members of Committee
J. Wilson, F.R.M.S.
J. Rudd Leeson, M.D., F.R.M.S.
C. S. Todd.
J. M. Offord, F.R.M.S.

FIFTY-FIRST ANNUAL REPORT.

Your Committee in presenting their Report for the year ending December 1916 scarcely need remind members that the Club during the whole of the time has suffered from difficulties caused by the state of affairs referred to in the Report for last year, some of them in even an increased degree. The lighting of the streets and the means of travelling have both been further reduced, increasing the difficulty of attendance for those residing at a distance. Though there has been a diminution in consequence, the average number present at the Ordinary meetings has been rather over fifty-five, and at the "Gossip" meetings rather over fifty-two, with a total individual attendance of 1,226 for the whole year. Your Committee consider this very satisfactory under the circumstances. During the year, thirty-one new members have been elected; this is more than in 1915, and the number could have been increased by five had there been the usual meeting for business in December. The resignations have been eleven, a great reduction on the loss due to this cause during the preceding year, when the number was twenty-five; eleven have been lost by death. The net result is an increase of nine, with a total membership of 458.

Mr. Dunstall's death took place in January. His energy and enthusiasm in the study of the Rotifera were well known, and his absence is marked with regret, especially at the "Gossip" meetings. Dr. Charters White, President in 1880–81, and in early days a very active member, passed away in March. Mr. C. Lees-Curties died in April. Mr. Enock, an Honorary Member, was lost to us in May. Mr. R. T. Lewis, one of the best-known members, who joined the Club in 1865, soon after its foundation, and had been since 1866 Hon. Reporter, passed away after a short illness in June. His familiar figure, his wonderfully regular attendance during fifty years, his frequent contributions to the *Journal*, and participation in discussions on the various communications, made him one of the most valued and appreci-

ated members, and one whose place it will be difficult indeed to fill. Obituary Notices of several of these will be found in the *Journal.*

The papers and notes communicated have been as follows:

Papers and Notes during the Year 1916.

January 25th.—Mr. G. T. Harris: On the Collection and Preservation of Desmids.

February 22nd.—Exhibition of Micro-objects by Mr. W. E. Watson Baker, with short explanation of the chief examples.

February 22nd.—The Presidential Address: Some Factors of Evolution in Sponges.

March 25th.—Mr. W. Milne, M.A., B.Sc.: On the Bdelloid Rotifera of South Africa.

April 25th.—Mr. Chapman Jones: On the Secondaries or Dotted Structure in the Pinnulariae.

April 25th.—Mr. A. A. C. Eliot Merlin: *Nitzschia singalensis* as a Test-object for the Highest Powers.

April 25th.—The President: On the Spicular Structure of the Sponge *Geodia japonica.*

May 23rd.—Photographs and Radiographs of Foraminifera, with explanatory remarks by Mr. E. Heron-Allen, President R.M.S.; and Mr. J. E. Barnard, F.R.M.S., on A Method of exhibiting the Internal Structure of Foraminifera by means of X-rays.

June 27th.—Mr. W. Traviss exhibited and described a new apparatus for collecting specimens in pond-work.

June 27th.—Mr. Wallis Kew: An Historical Account of the Pseudo-scorpion Fauna of the British Isles.

June 27th.—Mr. A. E. Hilton: On the Sporangial Characters of the Mycetozoa and the Factors which influence them.

October 24th.—Mr. David Bryce read Part II of Mr. W. Milne's paper On the Bdelloid Rotifera of South Africa.

November 28th.—The President on Gelatinous Sponge Spicules.

November 28th.—Mr. S. C. Akehurst, F.R.M.S., exhibited and described a tank and weed-holder for use with low-power objectives.

November 28th.—Mr. N. E. Brown: On the Seeds of *Anacampseros rubens*, and some Allied Plants from South Africa.

November 28th.—Mr. D. J. Scourfield: On the Volvocaceae, with reference particularly to a slide of *Pleodorina illinoisensis*, exhibited by him.

Your Committee, on behalf of the Club, desires to thank the authors of these communications. There have been no exhibits of new apparatus by the opticians, their energies being almost entirely taken up in meeting the demands of Government requirements.

The publication of the *Journal*, both the April and November numbers, has been somewhat delayed—especially the latter; this has been chiefly due to difficulties arising from shortage of labour at the printers, and our Hon. Editor deserves the sympathy of members for the extra work and trouble it has entailed.

The Committee would like to give some expression—in which they are sure the members will join—to their sorrow at the serious and long-continued illness of Mr. C. F. Rousselet, and to their sympathy with him.

The Librarian reports that the number of books issued to members during the year has been the same as last year, which is encouraging, as 25 per cent. more were taken out during 1915 and 1916 than in the two preceding years 1913–14; an indication that the members are showing an increasing interest in the Club's valuable collection of books.

In addition to the twenty-eight books added during 1916, there has been received from Mr. Rousselet a very interesting series of photographs of drawings, and drawings of Rotifera. These are being arranged for convenience of reference, and will shortly be available for the use of members.

List of Periodical Publications Received for the Year ending December 1916.

Academy of Natural Science, Philadelphia.
American Microscopical Society.
Birmingham Natural History Society.
British Association Report (Manchester, 1915).
California, University of.

Croydon Natural History Society.
Edinburgh Botanical Society.
Edinburgh Royal Botanical Gardens.
Geologists' Association, Proceedings of.
Glasgow Natural History Society.
Hastings and East Sussex Naturalist.
Hertfordshire Natural History Society.
Illinois State Laboratory, Natural History.
Indian Museum, Calcutta.
Manchester Literary and Philosophical Society.
Micrology, Journal of.
Missouri Botanical Gardens, Annals of.
Northumberland, Durham, Newcastle-on-Tyne Natural History Society.
Notarisia.
Nova Scotia Institute of Science.
Nyt Magazine.
Philippine Journal of Science. Sects. A, B, C, D.
Photomicrographic Society, Journal of.
Redia.
Royal Canadian Naturalist.
Royal Dublin Society, Proceedings of.
Royal Microscopical Society, Journal of.
Royal Photographic Society, Journal of.
Royal Society of London, Proceedings of. Series B.
Royal Society of New South Wales.
Smithsonian Institute, Annual Reports.
Tijdschrift.
Torquay Natural History Society, Journal of.
United States National Herbarium.
United States National Museum.
Victorian Naturalist.
Wisconsin Academy.

BOOKS PURCHASED.

Ray Society: BRITISH MARINE ANNELIDS. Vol. III. Part II. Plates. Prof. W. C. McIntosh, M.A., LL.D., F.R.S.

Ray Society: PRINCIPLES OF PLANT TERATOLOGY. Vol. I. W. C. Worsdell, F.L.S.

Ray Society: British Freshwater Rhizopoda and Heliozoa. Vol. III. G. H. Wailes, F.L.S.

Cambridge Botanical Handbooks. Vol. I. Algae. Prof. G. S. West, M.A., D.Sc.

Quarterly Journal of Microscopical Science.

The following books have been added to the Library during the year ending December 1916:

Presented by Henry Morland.

Index to the Localities named in Plates 1–288 of Schmidt's Atlas der Diatomaceen-kunde.

Presented by Alpheus Smith.

Elements of Entomology. W. S. Dallas.

Rambles of a Naturalist. 2 Vols. Quatrefages.

Q.M.C. Register for 1866–1876.

Presented by the Author, Prof. Arthur Dendy, D.Sc.

Reports on Calcareous and Non-calcareous Sponges, 1915–16.

Report of Sponges in the Indian Ocean, 1913–16.

Presented by the High Commissioner for New Zealand.

Subantarctic Islands of New Zealand. 2 Vols. Edited by Chas. Chilton.

Index Faunae Novae Zealandiae. Edited by F. W. Hutton, F.R.S.

Presented by the Author, Charles Janet.

Note Préliminaire sur L'œuf de *Volvox globator*. 1914.

L'alternance sporophyto-gamétophytique de Générations chez les Algues. 1914.

Presented by the Author, George West.

Principles of Photomicrography.

Presented by the Author, Wm. Milne, M.A., B.Sc., F.R.S.E.

Various Papers on the Rotifera and Infusoria. 1883–1914.

Presented by C. F. Rousselet.

Wild Fauna and Flora. Royal Botanical Gardens, Kew.

Transactions of the Middlesex Natural History Society. 1 Vol. 1886–92.

Northern Microscopist. 3 Vols. Vol. I., 1881; Vol. II., 1882–3; Vol. III., 1884.

Collection of Photographs of Drawings, and Drawings of Rotifers.

PORTFOLIO CONTAINING PRESERVED SPECIMENS OF FERNS OF NEW ZEALAND.

American Microscopical Society's Journal. 2 Vols., 33 and 34, 1914, 1915.

Received in exchange.

FORAMINIFERA OF THE NORTH PACIFIC OCEAN. Part V. 1915. Cushman.

Presented by the Author, HENRY WHITEHEAD, B.SC.

NOTES ON BRITISH FRESHWATER LEECHES.

Presented by the Society.

Journal of the Photomicrographic Society. 2 Vols. 1915–16.

EXCURSION SECRETARY'S REPORT.

During the year there were eleven excursions, all of which were successful, the average attendance being 17·3 against 17·6 in the previous year. Though no especially remarkable captures were recorded, the outings were much enjoyed by all, and it was felt that the social relaxation they afforded was of particular value to the members in these anxious times. Hearty thanks are due to Mr. Offord, who after conducting the Ealing excursion invited the members to his house, where they were kindly entertained at tea by Mrs. Offord. At the Richmond Park Excursion Mr. and Mrs. Wilson undertook a similar kind office, giving the excursionists a welcome and tea at their house at Kew. It is necessary also to express our indebtedness to the Royal Botanic Society and to Sir Phillip Sassoon for the permission to visit their private enclosures.

The Curator reports that during the past year the number of slides borrowed has been well maintained, nearly 2,000 having been lent. It has been a record year as regards additions to the Cabinets, 448 slides having been added, 409 by presentation. The principal of these have been over 100 very beautiful preparations of Diatomaceae and 60 various Botanical, from the collection of the late Mr. Dunstall. The sponge preparations placed at the disposal of the Curator by the widow of the late Mr. Priest have enabled the Club's collection of this group to be revised, and many defective slides replaced, bringing up the total number to 165 preparations, many of great interest and beauty. Mr.

Rousselet has recently made a further donation of 26 slides to his type collection of Rotifera, as well as three dozen other miscellaneous preparations. The Club has a useful memento of the late Mr. R. T. Lewis in the presentation of a collection of 31 slides of New Zealand Coccidiae, collected by Prof. Maskell. Mr. Offord has also given half a dozen historically interesting slides of microphotographs and micro-writings, done by the late Dr. Farrants about sixty years ago.

The incorporation of new preparations into the Cabinets, and the maintenance in good order of the existing slides, entail a large amount of labour, and the Committee regret that greater advantage is not taken of the Club's many valuable and interesting preparations, especially by the older members, and of which they evidently cannot be aware. The Curator will always be pleased to give any information on the subject.

The Committee suggest that members able to do so should bring their microscopes with some object for display to the Ordinary meetings. At one time it was the custom, after the regular business of the evening, for members to exhibit anything of interest they might have. It is much to be wished that more would make an effort to bring their instruments to the " Gossip " meetings, and thus increase the general advantage and interest. At present the number assisting in this way is in a minority.

The Committee as in previous years tenders its thanks to Mr. Bestow for his continued and valuable help in the Curator's department; and to Mr. Todd, who, as Assistant Librarian, has been of the greatest service. Mr. L. C. Bennett throughout the year has again given his efficient attention to welcoming visitors and newly elected members, and deserves the gratitude of the Committee and Club.

The Committee desires on behalf of the members to thank the various officers for the careful supervision they have given to the affairs of the Club during the very trying period which has been passed through. They feel it essential that, while present conditions remain, everyone should make an especial effort for the welfare of the Club; that it may, notwithstanding the untoward circumstances, continue to exhibit the usefulness and success which have characterised it in the past, and have continued to the present time.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1916.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance from 1915	113	3	5	By Rent	56	5	0
,, Subscriptions	138	10	0	,, Expenses of *Journal*	130	5	9
,, Dividends	14	11	8	,, Postage, etc.	5	1	0
,, Sales of Journal	14	11	5	,, Printing and Stationery	4	16	6
,, Advertisements	57	17	6	,, Attendant	6	6	8
,, Catalogues	0	4	0	,, Petty Expenses	2	9	0
				,, Books and Slides	7	12	3
				,, *English Mechanic*	7	10	10
				,, Balance in hand	118	11	0
	£338	18	0		£338	18	0

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

February 13th, 1917.

JAMES GRUNDY }
J. WILSON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

NOTE ON THE MEASUREMENT OF MAGNIFYING POWERS.

By W. M. Bale, F.R.M.S.

(*Read in Title October 23rd*, 1917.)

In this note, which, as will be apparent, is addressed mainly to those who, like myself, are unskilled in the science of optics, it is proposed to explain, somewhat more fully than is usual in the textbooks, how to construct a table of magnifying powers; and, further, to set forth the simplest possible means of ascertaining what power may be provided at any moment when, owing to alteration of the tube-length, the normal arrangement is departed from. If opticians always stated, as they should do, the initial magnification of each ocular and objective, it would only be necessary to multiply the two together to get the power of the combination, but neither this nor a complete table of powers would meet the case of those who, like many of us, possess a number of objectives and eye-pieces from a variety of makers.

Even if we have a completely fitted instrument with an accompanying list of magnifying powers, we must verify the latter, as these lists are sometimes very incorrect; indeed there are some respecting which it can be seen at a glance that they cannot possibly be correct. For whatever may be the powers of a series of objectives with a given eye-piece, it is obvious that by substituting a higher eye-piece the powers of all the combinations must be increased in the same ratio; *e.g.* if we have three objectives giving with an A eye-piece the respective powers of 50, 100 and 200, then if the B eye-piece increases the first power to 75, we know that it must increase the others to 150 and 300, and if an optician's list fails to maintain these ratios it must necessarily be wrong. To quote a case in point—I recently examined a cheap but good instrument with an accompanying table in which the powers of a one-inch and a quarter-inch with the lowest ocular are

stated as 40 and 80, and with a higher ocular as 156 and 415. Obviously if the substitution of the higher eye-piece doubled the power in the case of the one-inch, as stated, it would do likewise in the case of the quarter, and assuming 156 to be correct with the first eye-piece, the power with the higher would be 312, not 415. Actually, the powers of the four combinations, instead of being 40, 80, 156, and 415, as stated, are approximately 43, 75, 188 and 327.

Broadly speaking, there is only one way of measuring the magnifying power of a microscopical combination where the separate powers of the constituents are unknown, namely, by comparing the actual diameter of some object (usually the scale of a stage micrometer) with the magnified image of the same. This is most readily done by projecting the image of the micrometer-scale by means of some form of camera-lucida on to a paper at a distance of ten inches and marking some of the divisions on the paper, or even by projecting them on to a ruled scale, so that comparison is easy ; *e.g.* if one-hundredth of an inch when magnified equals one inch, the power is 100.

Thus far the textbooks ; but these directions leave room for a certain amount of error owing to their ignoring the fact that in all camera drawings the magnification is appreciably greater in the marginal portions of the field than near the centre. If we project the micrometer-scale across the field and mark off the divisions, we naturally select if possible so many divisions for comparison as will coincide exactly with one or more divisions of our rule, in order to avoid fractions ; and in one measurement we may attain this end by utilising only the central part of the field, while in another we may have to utilise nearly the whole. The result obtained in the first case should be correct ; the other will, with an eye-piece giving a large field, be 4 or 5 per cent. too great.

The procedure which I adopt to ascertain the magnifying power of a combination is as follows :

A.—Measure with the camera * the exact diameter (at 10 inches) of the *magnified* field.

* A Beale reflector is recommended, as it is an appliance so easily improvised if the microscope is not provided with one. The simplest method is to take a piece of wire, wind it two or three times round the eye-piece, twist the two ends together to keep it firm, and then, keeping

B.—Measure with the stage micrometer the *actual* diameter of the field.

Then A divided by B is the magnifying power.

It is to be noted, however, that the apparent diameter of the field, as projected by the camera and measured on the flat, is, for the reason before stated, excessive, and a deduction must be made, according to the rule to be stated farther on, to compensate for the uneven magnification.

Example.—The apparent field-diameter, as measured on the flat, is 5 inches, or 127 mm. We deduct 3 millimetres, making the effective diameter 124 mm. The actual diameter of the field, as shown by the stage micrometer, is 0·62 mm. Then 124 ÷ 0·62 = 200, which is the magnifying power.

The diameter of the magnified field of view depends solely on the eye-piece diaphragm; it is therefore a constant quantity, which when once measured may be recorded for future reference. If preferred it may be scratched on the eye-piece tube.

As soon as all the eye-piece fields have been measured and recorded there is no further need for the camera, or for any other accessory than the stage micrometer; the microscope is used in its ordinary position, and the power of each eye-piece tested in combination with each objective till the table is completed. The same simple process enables us to find at once what power we are using at any time when, owing to variation of the tube-length, our standard scale is not applicable; a useful feature in these days when the common use of such imperfect appliances as fourths and sixths without cover-correction must, one would think, lead to a continual pushing in and out of draw-tubes.

I may here note a few points which require attention when making our measurements, if reasonable accuracy is to be obtained. We must see that all draw-tubes are pushed home, unless it is preferred that the magnifications should be taken with a 10-inch tube-length, when the tube must be set accordingly. The objective collar must be looked to, as its position appreciably affects the power. I have found that with a $\frac{1}{4}$-inch

the ends slightly apart, bring them up from the lower side of the eye-piece at an angle of 45 degrees, so that a thin cover-glass laid upon them will reflect the image of the field, apparently upon the paper. I have tried this expedient, which only took about three minutes to carry out, and it was quite as efficient as the ordinary Beale reflector.

objective, in combination with an eye-piece giving a power of about 370 diameters, there was a difference of about 22 diameters between the results obtained when the collar was set at the two extremities of its range. It should be set at a position suitable for average slides, and always brought to that position when measurements are to be taken. The fine adjustment should be at about the centre of its range, if it is one of those which act on the nose-piece only. I suppose it will rarely happen that the field-diameter will vary in different directions, yet I have in one instance found a slight variation, owing to the diaphragm not being truly circular. In such a case the eye-piece may be marked so as to show which diameter is taken. If a pair of eye-pieces is in use they should be tested to see if the fields are equal; if not, one only should be used for measurements.

Having done the sums it remains to prove them, which we can easily do by proportion. As the power of, say, a 1-inch with a certain eye-piece is to the power of a one-fourth with the same eye-piece, so will be the power of the 1-inch to that of the one-fourth with any other eye-piece. If on making a series of comparisons like this the results correspond fairly with the figures obtained by measurement, we may be satisfied; if not, we must conclude that there is an error somewhere. In a few instances it may probably be found that the field measures an *exact* number of micrometer-divisions without fractions; the results in such cases should reach a high degree of accuracy, and should be relied upon rather than those in which there have been fractions to estimate. For example, a 2-inch objective with a $\frac{1}{4}$-inch eye-piece gave a field which measured 26 thousandths with the inch micrometer, and 66 hundredths with the millimetre micrometer. The effective magnified field-diameter was $6\frac{3}{16}$ inches, or 157 millimetres; the respective results therefore were 237·98 and 237·87 diameters.

Of course if we are certain that we have ascertained correctly the powers of our whole series of objectives with any one ocular, it will suffice to measure the powers of each of the other oculars with one objective only, and then the powers with the other objectives can be found by proportion.

We will now revert to the subject of the deduction to be made from the apparent field-diameter to compensate for the unequal magnification of the different zones of the field. When we speak

of making a drawing at 10 inches distance we are apt to forget that it is only that part of the drawing immediately below the

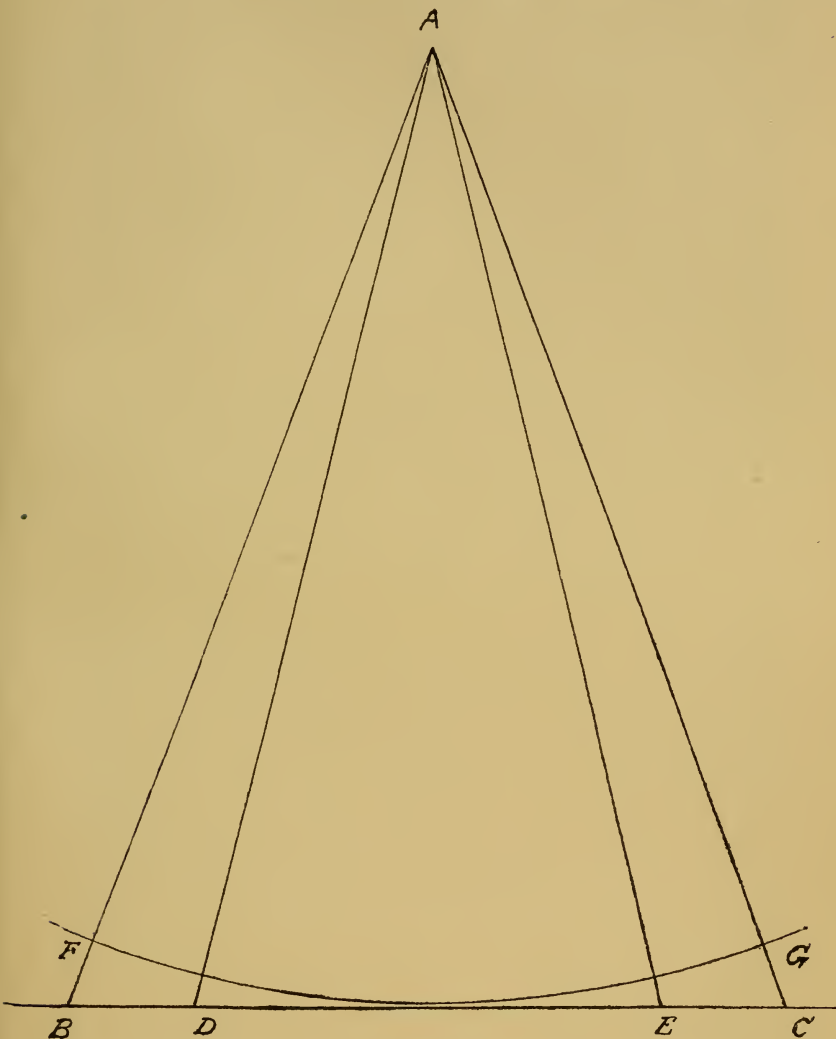


FIG. 1.

camera (*i.e.* the centre of the field) which is at that distance, other parts of the drawing being more distant in proportion as

they approach the edge of the field, and consequently being more magnified. This will be best exemplified by making a diagram similar to that given here (Fig. 1) but of the full size (which is twice the diameter of the print). Assuming that the microscope is placed in the usual position for drawing, A is the centre of the eye-piece, and B C the surface for drawing on, the centre of which must be 10 inches from A. The distance from B to C, $7\frac{1}{2}$ inches, represents the apparent diameter of the field, as projected on the paper, this being the field of a Swift B ocular which gives the largest field of any of my eye-pieces. Similarly D E, $4\frac{7}{8}$ inches, represents the apparent field of a Swift A. We see at once that rays apparently proceeding from about the margin have a considerably longer path than those from the centre, and the exact difference can be readily measured if we describe the arc F G, having a radius of 10 inches from A. We see that while objects at the centre of the field are drawn at a distance of 10 inches those at B or C are drawn at about $10\frac{11}{16}$; their magnification therefore exceeds that of objects at the centre in the same ratio as that in which 10 exceeds $10\frac{11}{16}$; so that, supposing the central part is magnified 100 diameters, the marginal part will be magnified nearly 107, and the field-margin will appear farther from the centre than it should. Let the arc F G be divided into 12 or 15 equal parts, and let lines be drawn from A through each of the divisions to the line B C, and we shall see that the divisions on B C are not all equal, those near the margins being slightly longer, as the micrometer-divisions would be on a drawing. Now, while the line B C is the apparent field-diameter as shown in a camera-drawing, the real field-diameter, as taken at a uniform distance from A of 10 inches, is the length of the curved line F G. To measure this accurately the simplest way is to cut the paper along F G and apply a flexible rule to the margin, when it will be found that the field, which measures $7\frac{1}{2}$ inches in the camera-drawing, is really about $7\frac{3}{16}$. Of course with an ocular of small field the difference will be much less, as is conspicuously shown in the diagram.

Instead of making a diagram we may proceed as follows: take a strip of cardboard and bend it to the curve of the arc F G, place it under the camera and prop the ends, holding it in such a position that every part will be 10 inches from the centre of the eye-piece, then mark on it the positions of the opposite edges

of the field, as projected by the camera, when the field-diameter so shown will be $7\frac{3}{16}$ inches, corresponding to the line $F\ G$.

The observer who proposes to calculate his magnifying powers by the foregoing method must of course substitute for the distances $B\ C$ and $D\ E$ distances representing the apparent fields of his own eye-pieces, and must be careful to secure accuracy, as the correctness of all future measurements will depend upon it. It is well to record the field-diameters in inches as well as in millimetres, to be handy for reference when using either micrometer. But for all ordinary purposes it will suffice to use the following table, which, it is believed, is correct to the nearest millimetre. The first two columns show the field-diameters as seen in a camera-drawing, the third the amount to deduct. The remainder is the proper field-diameter to be used in calculating magnifying power:

4 inches . . .	= 101 millimetres,	deduct	1 mm.
$4\frac{1}{2}$,, . . .	= 114 ,,	,,	2 ,,
5 ,, . . .	= 127 ,,	,,	3 ,,
$5\frac{1}{2}$,, . . .	= 140 ,,	,,	4 ,,
6 ,, . . .	= 152 ,,	,,	5 ,,
$6\frac{1}{2}$,, . . .	= 165 ,,	,,	6 ,,
7 ,, . . .	= 178 ,,	,,	7 ,,
$7\frac{1}{2}$,, . . .	= 190 ,,	,,	8 ,,
8 ,, . . .	= 203 ,,	,,	9 ,,

While I have not seen this matter referred to in any book specially in connection with the measurement of magnifying power, I note that Mr. A. C. Cole, in his *Methods of Microscopical Research*, refers to the distortion in drawing with the camera, and somewhat drastically proposes that no eye-piece higher than an *A* should be used for drawing with. This rule seems to limit one's use of the instrument unnecessarily. The distortion is mainly due, not to the greater power of the eye-piece, but to the greater actual size of its field; therefore the ratio of distortion will be no greater with a *B* or *C* eye-piece than with an *A*, provided that we only utilise so much of the field of the former as will correspond with the field of the *A*; or better still (since there is some distortion even with the *A*), if we confine our drawing with all eye-pieces to, say, not more than 4 inches in the centre of the field, shifting the paper from time to time so as to keep within that area. Obviously the only way to get a camera-drawing with equal magnification throughout a large field would be to

make the drawing on a concave plaque of such concavity that all parts of its surface would be equidistant from the optic axis of the eye-piece.

Of course camera-drawings are made at all sorts of distances from the eye-piece, in order to obtain particular magnifications ; and when they are made at other than the 10-inch distance, the foregoing rule will obviously not apply. But in all cases when using the camera the simplest way of indicating the magnification is to mark off on the paper a few divisions of the micrometer scale, placing the paper so that the part where the divisions are to be marked is immediately under the camera.

THE MEASUREMENT OF MAGNIFYING POWER: A NOTE ON MR. BALE'S PAPER.*

By Maurice A. Ainslie, R.N., B.A., F.R.A.S.

The method described by Mr. Bale of measuring the magnifying power of a microscope is not by any means new; it was described by Mr. Nelson in a paper read before the Quekett Microscopical Club (*Journ. Q.M.C.*, Ser. 2, vol. xii. p. 239), and in the *English Mechanic* for August 1st and 15th, 1913 (Nos. 2523 and 2525) will be found two letters of my own, giving several methods of determining the diameter at 10 inches (or any other specified distance) of the magnified field as seen through the eye-piece. But Mr. Bale does well to call attention to this method again, as it is without doubt one of the easiest as well as one of the most satisfactory methods of arriving at the magnifying power of the instrument as a whole, and also on account of its having been hitherto so much, and so unaccountably, neglected by writers on the microscope. The practical details of procedure given by Mr. Bale are of great value; but there are one or two points to which I should like to draw attention, as being open to objection.

In the first place, Mr. Bale is not quite correct in stating that "by substituting a higher eye-piece the powers of all the combinations must be increased in the same ratio." This may be the case, but it is not necessarily so. For in the first place the substitution of one eye-piece for another very often alters the tube-length; since this latter is properly measured from the upper focal plane of the objective to the image plane, which for normal eyes coincides with the lower focal plane of the eye-piece. At any rate, the magnification produced by the objective alone

* The Hon. Editor is very much indebted to Mr. Ainslie for kindly reading the MS. of Mr. Bale's paper and for adding the above note.

is proportional to this "optical tube-length," and since different eye-pieces, when in position in the tube, very often have their lower focal planes at widely different distances from the top thereof, it follows that the magnification due to the objective is often altered by change of eye-piece. This is, in fact, always the case if any refocusing is required on change of eye-piece; and for this reason, as well as for the purpose of retaining the tube-length (on the correctness of which the proper performance of the objective so much depends) it is always desirable, on changing the eye-piece, to restore the focus, if necessary, by alteration of the tube-length.

But quite apart from this, there is another reason why the powers given by different combinations do not always follow the strict rule of proportionality as stated by Mr. Bale; the magnifying power of the objective, as stated above, is strictly proportional to the "optical" tube-length, as mentioned above, and not to the "mechanical" tube-length, which is the actual length of the tube, measured from top to bottom. The optical tube-length of course varies with the position of the upper focal plane of the objective; in one objective this may be as much as 50 mm. below the bottom of the tube, while in another it may be as much as 50 mm. above it; so that, even with the actual length of the tube unaltered, there may be a variation, with different objectives, of as much as 100 mm. in the optical tube-length, quite apart from the variation introduced by change of eye-piece. It is obvious that if the optical tube-length is thus altered by change of objective, the power of the objective ceases to be inversely proportional to its equivalent focal length; or, to put it in more popular language, a "quarter" will not necessarily magnify four times as much as an "inch."

It thus follows that it is not such a simple matter as it might seem to compute the magnification of one combination from that of another; indeed, it is impossible to do so with any real approach to accuracy unless the positions of the upper focal plane of the objective, and of the lower focal plane of the eye-piece, are taken into account.

An actual example may help to make this clearer. I have measured the magnifying powers with two objectives—the Leitz No. 1, focal length 39·4 mm., and the Zeiss 12-mm. Apo., focal length 12·6 mm.; and two eye-pieces, the Holos "10," actual

power 9·4, and the Zeiss Compensating "8," actual power 11·8. The results are given in the following table:

Eye-piece	Holos "10"	Zeiss "8"	Zeiss "8"
Power of eye-piece	9·4	11·8	11·8
Tube-length (mechanical) in mm.	167	167	185
Distance of lower focal plane of eye-piece below top of tube, in mm.	−3	+15	+15
Magnifying powers with:			
Leitz No. 1	33·8	37·0	42·4
Zeiss 12-mm.	142·0	160·5	178·0

The upper focal plane of the Leitz No. 1 objective is 28·5 mm. *above* the lower end of the tube; that of the Zeiss 12-mm. is 19·8 mm. *below* the same. It follows that the *optical* tube-lengths were as follows in the three cases:

Leitz No. 1	141·5	123·5	141·5
Zeiss 12-mm.	189·8	171·8	189·8

and the magnifying powers of the objectives by themselves (optical tube-length divided by focal length of objective) were:

Leitz No. 1	3·59	3·14	3·59
Zeiss 12-mm.	15·05	13·63	15·05

(The difference between the second and third columns is due to the fact that for the second column the refocusing necessitated by change of eye-piece was performed in the ordinary way by the coarse adjustment; for the third column, by pulling out the draw-tube, so as to adjust the lower focal plane of the eye-piece to the image, the position of the latter being unaltered; in other words, the "optical" tube-length is the same for columns one and three, but not for columns one and two, as will indeed be seen from the table.)

It will be obvious from the above table:

(1) That the magnifying power with the same eye-piece is *not* inversely proportional to the focal length of the objective; this is due to the great difference (in this case 19·8 + 28·5, or 48·3 mm.) between the positions of the upper focal planes of the two objectives considered. In the present case the ratio of the

focal lengths of the objectives is 39·4/12·6, or 3·125; but the magnifications, in the case of the Holos "10" eye-piece, are in the ratio of 4·08 to 1, and in the case of the Zeiss eye-piece, 4·33 and 4·20 to 1, according as the focus was readjusted by the coarse adjustment or the draw-tube.

(2) That the magnifying power is not proportional to the power of the eye-piece, unless the optical tube-length is unaltered by change of eye-piece; the numbers given in columns one and three for the magnifying power are proportional to the powers of the eye-pieces, while those in columns one and two are not. The substitution of the Zeiss eye-piece for the Holos, *without alteration of tube-length*, increases the power 9·3 per cent. in the case of the Leitz No. 1, and 13 per cent. in the case of the Zeiss 12-mm., the ratios being 1·093 and 1·13 to 1 respectively. Neither of these equals the ratio of the powers of the eye-pieces, which is 1·255 to 1. Thus if the magnifying power were merely computed as proportional to the powers of the eye-pieces, an error would be introduced which would be greater in the case of the low-power objective than in that of the high.

(3) The percentage difference between the magnifying powers in columns two and three is greater in the case of the low-power objective: 14·6 as against 10·8 in the case of the 12-mm.

It is therefore obvious that it is unsafe to attempt to compute the magnifying power of one combination from that of another, unless the positions (relative to the ends of the tube) of the various focal planes are known; in the absence of such knowledge, the power of every combination must be separately determined. It is only fair, however, to say that the case here taken is rather extreme, though by no means so extreme as it might be; if objectives (say a $\frac{1}{4}$ and an $\frac{1}{8}$) or eye-pieces of the same type are compared, the errors in the result are as a rule considerably smaller.

The error pointed out by Mr. Bale, due to the increase of linear magnification at the edge of the field, undoubtedly exists; but I am not sure that it admits of quite such simple treatment as he has indicated. Apart from the geometrical distortion which he has dealt with, there exists in almost all eye-pieces a certain amount of optical distortion of the image, towards the edge of the field, and this optical distortion might very easily affect the results obtained; and it varies very considerably with the type

of eye-piece employed. Again, the term "magnifying power" may either mean the ratio of the linear dimensions of the image (supposed projected to some conventional distance, *e.g.* 10 inches or 250 mm.) to those of the object; or it may mean the ratio of the angles under which the image and object are seen, both being supposed at this conventional distance. If the latter meaning of the term be adopted, it would seem that there is no real distortion of the kind mentioned by Mr. Bale; and the only distortion would be that of an optical nature already alluded to; but if it is a case of linear ratio, then we must assume the image projected on a plane surface, in which case the degree of flatness of field of the microscope would enter into the matter. I do not know that it really much matters, even at the edge of the field, which way we look at the matter; but it is worth while mentioning. As far as the centre of the field is concerned, there is of course no difference.

Mr. Bale states that, broadly speaking, the method he describes is the only one available in the absence of knowledge of the separate powers of the constituents of the microscope. It is therefore, I think, desirable to call attention once again to a method which has as yet received but scant treatment from the textbook writers; I refer to the Measurement of the Ramsden Disc, or spot of light seen just above the eye-piece. I have given full directions for this method in a letter to the *English Mechanic*, August 15th, 1913 (one of the letters already alluded to), and also some details in a lecture before the Photomicrographic Society (see their *Journal*, February 1916, vol. v., No. 1). I will therefore only mention here that the formula employed is

$$M = 2D.A/d,$$

where M is the magnifying power of the instrument as a whole, D the conventional distance of the image from the eye (10 inches, or 250 mm.), A the N.A. of the objective (which for this purpose must have its full value, *i.e.* must not be cut down by the substage iris diaphragm), and d the diameter of the Ramsden Disc. The latter can be measured by various methods; *e.g.* Banks' "Dynameter," Berthon's "Dynamometer," or a finely divided scale. As an example suppose $D = 10$ inches, $A = 0{\cdot}84$, $d = 0{\cdot}035$ inch, then $M = 20 \times 0{\cdot}84/0{\cdot}035$, or 480 diameters. The great advantage of this method is that, given the N.A. of

the objective, only one measurement is required, and that it is quite independent of the power of objective or eye-piece, or of the tube-length; it can be applied at any moment, without altering any of the adjustments of the microscope, beyond opening out the substage iris to its full extent, and without in any way disturbing the object under examination; and it is especially easy to apply when dark-ground illumination is in use, as the Ramsden Disc, though faintly illuminated, is then as a rule quite easily seen, and if anything, more easily measured than a bright disc. Its only drawbacks are that it really requires a special instrument of some sort for measuring the R.D.—this, however, is not difficult to improvise—and that when the R.D. is small the accuracy of the method rather falls off, though it is still, unless the R.D. is abnormally small, quite sufficient for all ordinary purposes. For further details, especially in regard to the use of this method when an immersion lens of N.A. greater than unity is in use, I must refer the reader to my letters to the *English Mechanic* already mentioned.

I may also mention that this method is analogous to the ordinary method for finding the magnifying power of a telescope, for which M equals A/d, where A and d are the diameters of the object glass and Ramsden disc; both of these formulae are easily proved by means of what is known as the "sine-law."

SOME FURTHER NOTES ON COLLECTING AND MOUNTING ROTIFERA.

By C. F. Rousselet, F.R.M.S.

(*Read in Title October 23rd,* 1917.)

Since 1893 I have published various memoirs on my methods of preserving and mounting Rotatoria, which from time to time have been modified and improved upon. It is my belief that I have now succeeded in arriving at a fair degree of perfection for fluid mounts and securing a really lasting method of mounting such slides, and it is my object in the following pages to recapitulate the steps which have led to this result, some of which have not been recorded before. The members of the Q.M.C. need scarcely be told how Rotifera are caught and examined; I will therefore only briefly mention the methods I have used for years for collecting them in large numbers and with the least possible difficulty. The starting-points for these methods I learned at my first attendance at the Q.M.C. excursion meeting in May 1883, in the north of London, probably Hampstead Heath, led by Mr. John Hardy. I collected from the very first with the Q.M.C. collecting-stick and net, as sold by C. Baker. The collecting-stick in the shape of a walking-stick with a telescopic joint, so that its length may be nearly doubled when required, was invented by Mr. Highley about 1868, as mentioned by Lionel S. Beale, F.R.S., in the 4th edition of his book, *How to Work with the Microscope* (p. 147), and figured on pl. 35, fig. 224. The net is an old Q.M.C. institution and was probably introduced by Mr. Thomas Curties, of C. Baker's firm. It was at first made with the thin muslin known as soft mull, but later on I introduced silk (bolting silk No. 15 or 16) made in Switzerland

and now obtainable at a firm of mill furnishers in Mark Lane, Bryan Corcoran & Co. This material lasts much longer and does not clog or shrink so much as the former. The shape of the ring net has always been the same as long as I am able to remember it; its size $6 \times 5\frac{1}{2}$ inches wide, 6 inches long. The little bottle I devised myself, making it $3\frac{1}{2}$ inches long by $1\frac{1}{4}$ inch wide, of clear crown glass with a rimmed edge at one end. It was made for me by a glass-blower of High Holborn named Müller.*

When out collecting I used to fill one or two large square bottles, and on arriving home I emptied their contents into a couple of parallel-sided aquaria of various and suitable sizes. These aquaria appear to have been first introduced by Thomas Bolton, of Birmingham, and were exhibited by him at the International Fisheries Exhibition held in the year 1884, at South Kensington. The size was originally 6 inches by 1 inch in depth from back to front, which I considered rather too small, so I had some constructed of a slightly larger size, 7 inches by $1\frac{1}{4}$. which answered admirably.

About 1889 I invented a tank microscope with an arm carrying an aplanatic 6 mm. lens, so jointed that the lens could be moved at pleasure parallel with the glass front of the tank and having focusing adjustments by rack and pinion. At first this apparatus was fixed by screw-clamp to the tank itself, but afterwards Mr. Charles Lees Curties suggested that it should have a separate wooden base to enable me to replace one tank by another when desired, without having to shift the clamp.

After a few hours' "rest" all the impurities and debris had

* The same glass-blower made for me two kinds of glass pipettes: (1) Fairly strong glass tube $\frac{1}{4}$–$\frac{5}{16}$ inch in width, 8 inches in length, with the end drawn out gradually from the middle, for use with a red non-perforated indiarubber teat (obtainable from Messrs. Baird & Tatlock, of 14, Cross Street, Hatton Garden, E.C.); (2) Finer tube, 6–8 inches long, with a funnel-shaped head, to be covered with thin indiarubber membrane (such as is used to repair the inner tubes of cycle tyres), by means of which single Rotifers, or a few, can be picked up by the varying pressure of a single finger on the membrane and so transferred to wherever may be desired.

settled down and the water had become sufficiently clear to be examined with the hand lens. The aquarium having been placed on a whatnot or dinner-waggon before a window or in front of a lamp, candle or electric light, all the free-swimming Rotifera collected on the side nearest the light and could then be picked up by the score or hundred with very little dirt by means of a pipette fitted with an indiarubber teat, and transferred to one of my solid watch-glasses,* which being placed on the stage of my Stephenson binocular enabled me to examine them under a low power (3 inches).

Any form unknown or new to me could then be picked out and transferred to the micro-glass trough or to my live-box or screw compressor for further examination with the 1½ inch or higher power, and under dark-ground illumination.

After this preliminary selection the Rotifers in the solid watch-glass were first of all narcotised with 1 per cent. eucaïne and then fixed and killed with one drop of ½ to ⅛ per cent. osmic acid, left there for one minute only and then removed by means of a pipette to several changes of 2½ per cent. formalin, in which they were finally mounted. Formerly I recommended washing in distilled water, but the difference in density caused some species to swell too much. This swelling can be controlled and regulated by increasing or decreasing the percentage of formalin.

The 1 per cent. solution of osmic acid sold by opticians is as a rule very much weaker than its nominal strength, as the acid evaporates and gradually disappears; moreover a 1 per cent. solution will blacken and spoil the specimens if they are kept in it even a very short time. For this reason and so as to know the actual strength of the solution I was working with, I found it

* In the early days my friend Mr. Dixon Nuttall had cut for me by one of his friends a number of squares of thick plate glass, 1½ to 2 inches square, and varying from ⅜ inch to ½ inch in thickness. In the centre of each square of glass I caused to be ground a cavity more or less deep. These solid watch-glasses, as I called them, could not only be placed singly upon the stage of my dissecting microscope, but when not so used could be placed one upon the other to protect the contents from dust, etc.

necessary to prepare it freshly every three or four months by dissolving the contents of a $\frac{1}{10}$ gram osmic acid capsule, breaking the sealed glass tube in 10 grams of distilled water. This gives a 1 per cent. solution which can be further diluted as required.

Having narcotised, fixed and killed the Rotifera, and having passed them through the several changes of formalin solution, the solid watch-glass was transferred to the stage of the Stephenson binocular and the contents examined under a 2-inch objective. (In speaking of my Stephenson binocular I ought to mention that it was a Swift model without any condenser or sub-stage illuminating apparatus, but with the body so mounted and arranged that it could be turned aside when not wanted, thus leaving the stage quite free for manipulation and the movement of the solid watch-glass and specimens.) The different species could then be sorted out by means of a single bristle (taken out of an old well-worn clothes-brush and mounted in a suitable handle), and isolated in a micro-cell either singly or collectively, the specimens being picked up and transferred by the fine pipette.

The greatest difficulty I had was with Floscularia and Stephanoceros. The latter I at last succeeded in preparing fully extended in the following way:

I cut off small pieces of weed having one or more animals attached, as a rule six specimens in all; each of these I trimmed as if ready for mounting. I then placed each of them separately in six different solid watch-glasses, with a pipette full of perfectly clear filtered pond-water to which I added one drop of 1 per cent. solution of Beta-Eucaïne, never using or attempting to use more of the narcotic. At first the animals contracted violently and assumed all manner of shapes. After a time, 10 to 15 minutes, they became quiet, and then I watched them under the Stephenson binocular until 20 or 30 minutes had elapsed, when I killed and fixed the first one by adding one drop of $\frac{1}{4}$ per cent. osmic acid. If this failed I tried the next one five minutes later and so on, until I succeeded in fixing the specimen

nicely and fully extended. Being then sure that those remaining were sufficiently narcotised, they were killed in the same way, and each, when fixed, was immediately removed with a pipette into 2½ per cent. formalin and then transferred again through several changes of the formalin solution so as to get rid of all trace of osmic acid. Finally the specimen was transferred to a cavity slide, covered and finished in my usual way.

In preparing non-free-swimmers I was greatly assisted by Mr. Traviss's cutting and holding scissors,* by means of which a small bit of pond weed to which the animal is fixed or attached can be cut and transferred at pleasure.

In later times I have ringed my slides first of all with a very thin ring of picture copal varnish followed by a coat of Japan gold size, and then with several coats of Heath's cement (gold size-shellac-indiarubber), finally finishing with three more coats of gold size. Several persons beside Mr. Heath have produced a micro-cement containing gold size and pure rubber, and with the assistance of Mr. Waddington I have myself compounded one containing pure caoutchouc dissolved in mineral naphtha and mixed with gold size and Canada balsam. This appears to answer very well, and to be a solution of a problem which has puzzled microscopists for many years. Messrs. Clarke & Page seem to have produced a cement with similar ingredients and properties, and Flatters & Garnett have also done the same under the name "Brown Ringing Cement," the actual composition of which is kept secret, but, I take it, it contains a small proportion of indiarubber, which appears to be essential. I hope that Mr. Heath will get a reputable gold size and

* Traviss's cutting and holding scissors were first made by him on the principle of a grape scissors which holds the grape that is being cut off. More recently I advised Mr. Traviss to have his scissors plated or made of nickel silver to prevent the blades rusting, and also to have the handles made a little longer, say 4½ to 6 inches long, to enable me to cut off a piece of weed with the animals attached thereto under water in my window aquarium, to be then transferred to the solid watch-glass, micro-trough, etc.

lac manufacturer to prepare his cement so that it may always be obtainable at a reasonable price and in small quantities.*

The glass micro-cells require a further word. At first I had great difficulty in obtaining suitable sunken glass slips. The first specimens were obtained from Birmingham, but the polishing of the cavities was so rough and faulty that I gave them up. After a time I discovered a firm in Hanover † where I could obtain everything I required. Opticians here used to charge me 2*d.* each for very inferior glass slides, but from this firm I was able to obtain them finely polished at a wholesale price costing less than 10*s.* a hundred.

Some years ago I also gave considerable attention to freshwater Polyzoa. My method of narcotising, fixing and mounting has been fully described, with some additional methods of his own, by Mr. H. E. Hurrell, F.R.M.S., of Great Yarmouth, in the *Micrologist*, part 2, vol. iii., January 7th, 1916, published by Mr. Abraham Flatters, 16–20, Church Road, Longsight, Manchester. I therefore need say nothing more on the subject. Polyzoa require a larger cell for mounting than Rotifera, and on this point I have some further remarks to make. After a considerable search I found at Flatters & Garnett's some well-cut glass cells (probably obtained from some makers in Germany), cut and ground on both sides. These I treated in my own way by painting on three successive coats of one of the caoutchouc-gold-size cements, all within three days. I then dropped each of

* Last year Professor Topsent of Dijon informed me that M. Radais, Professeur a l'école de Pharmacie de Paris, had lately prepared a cement to close preparations mounted in water. Owing to the war I have been unable to ask for or to obtain this cement.

At an earlier date Mr. A. B. Aubert of New York City sent me a small bottle of Micro-cement, which, however, I was unable to try at the time, but as far as I can remember he mentioned that rubber was one of its constituents. This year I wrote to him asking him for particulars and details of its constitution. My letter, however, never reached him.

† The firm is called Deutsche Spiegelglas Actien-Gesellschaft, in Freden a/d Leine, Provinz Hanover, Germany. English glass manufacturers might take the hint to produce white glass micro-slides of equal quality and finish.

these cells on the centre of a cavity cell slide and placed the slide on a metal table with spirit lamp underneath, which could be removed occasionally until I could see that the cement adhered all round. Great care must be observed that the heat be not too great or bubbles will appear in the cemented ring.

The slides thus prepared can be put aside till wanted. When the time arrived I used to run a ring of Clarke & Page's cell cement on the clean surface of the glass cell, and allowed this to dry for twelve to twenty-four hours. Having previously selected a cover-glass which very slightly overlapped the diameter of the cell, say by not more than $\frac{1}{16}$ inch or $\frac{1}{32}$ inch, I filled the cell with the mounting fluid ($2\frac{1}{2}$ per cent. formalin) and placed in it the prepared specimen, leaving it there for a short time so as to enable me to prick any air-bubbles with a needle or single hog's bristle. I then filled the cell just full with as little as possible of this fluid and placed one drop of fluid on the cover-glass, which was lowered on to the cell and adjusted, using hardly any pressure, the surplus fluid being taken up first with a pipette and then with thin blotting paper or cigarette paper. After two or three hours' time it will be necessary to examine the slide under the preparing microscope to see that the cover is properly sealed all round the edge, and, if need be, to add a drop of cement. If this is found quite satisfactory the slide can be put aside for three or more days, when further coats of Heath's or Clarke & Page's or Flatters & Garnett's cement are to be added, leaving each coat three days to dry before adding the next.*

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* My slides of Rotifera and Polyzoa were presented to the Natural History Section of the British Museum at South Kensington, where they may be examined on application to the curator.

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NOTE.

TECHNICAL OPTICS.

Arrangements have recently been completed for an important development in national industry on the scientific side, by the establishment of a new Department of Technical Optics in connection with the Imperial College of Science and Technology at South Kensington. The Department in question forms part of a larger scheme adopted by the London County Council in August last for the provision of instruction in this most important subject (in which the Council promised to find certain moneys for the scheme, if the Government also contributed), including post-graduate and research work at the Imperial College, a trade school and senior day and technical courses at the Northampton Institute, and junior technical courses at two junior technical institutions, one in North London and one in South London.

Since August last the Government, including the new Department of Scientific and Industrial Research and the Imperial College, have decided financially to support the Council's scheme, and all the necessary assents have been obtained. The amount of money immediately available is £4,000 a year for working expenses and £5,000 for equipment and more immediate necessities of the Department.

The new Department is under the management of a Technical Optics Committee of which the Right Hon. Arthur H. D. Acland is Chairman, and which at present consists of thirteen members representing the Admiralty, the Army Council, the Ministry of

Munitions, the Royal Society, the National Physical Laboratory, employers in the optical trades, glass manufacturers, and the Imperial College; while two further members have yet to be elected representative of glass workers and metal workers. The same Committee appointed by the L.C.C. is also an Advisory Committee to the Council.

Mr. Frederic J. Cheshire has been appointed head of the new Department at the Imperial College for a period of five years, with the title Director of Technical Optics, and Professor of Technical Optics at the Imperial College. Mr. Cheshire's long experience and great ability in optical matters practically ensure a successful beginning. He has been associated with optical instruments for many years at the Patent Office, and since the formation of the Ministry of Munitions has been Deputy Director-General of the Ministry and Technical Director of the Optical Department of the Ministry. He is the present President of the Optical Society.

It is expected that, subject to the conclusion of certain arrangements with the Treasury, Mr. Cheshire will accept the Directorship, and it is anticipated that the organisation of the Department will be rapidly completed, and that training will begin at an early date.

June 1917.

The recently established Department of Technical Optics of the Imperial College at South Kensington has now begun its work. It will be remembered that on the initiative of the London County Council a general scheme for providing instruction in this highly important national work was agreed upon by the several parties concerned in the early part of the year when an Advisory Committee to the County Council representative of the

trade, the workers and other interests concerned was appointed under the chairmanship of the Rt. Hon. A. H. Dyke Acland.

An important part of the scheme was the establishment of the above Department, which is administered under the Governors of the College by the same Committee. In June Prof. Frederic J. Cheshire was appointed Director of the new Department; in July Prof. A. E. Conrady was appointed to the Chair of Optical Design, and other subordinate appointments are in hand.

During the summer two courses of lectures were given on the designing and computing of telescope systems, and attended by sixty-six students, of whom forty-two came direct from the workshop—a gratifying indication of the recognition by the manufacturers of the importance of this work. About twelve of these were men of academic distinction. The Ministry of Munitions, the National Physical Laboratory, the Royal Observatory and Woolwich Arsenal were well represented.

This Session well-attended courses are being given in Optical Designing and Computing, Practical Optical Computing, the Construction, Theory and Use of Optical Measuring Instruments, Theory of the Microscope and Microscope Technique. Every effort is thus being made to meet the more immediately urgent demands arising in connection with the war. A complete curriculum for Optical students will be introduced as soon as the exigencies of the time permit.

The courses on the Theory of the Microscope and Microscope Technique now in progress constitute the first effort of the Technical Optics Department under the direction of Prof. Cheshire to meet the needs of the users of optical instruments. The microscope is perhaps the most important of all optical instruments and the one for which there is the greatest commercial demand, but unfortunately an exceedingly small propor-

tion of that demand has been satisfied hitherto by English manufacturers. It is hoped therefore in the courses referred to above to excite a wider interest in the designing and production of the microscope, and at the same time to insist upon the necessity for greater technical knowledge and skill in its use.

The course on the Theory of the Microscope is being given by Prof. Conrady and by the courteous permission of Dr. Burrows, the Principal of King's College, the course of lectures on Microscope Technique will be given by Mr. J. E. Barnard, Lecturer on Microscopy at that College.

NOTICES OF BOOKS.

On Growth and Form. By D'Arcy Wentworth Thompson. xvi + 793 pages, with 408 illustrations in the text. 9 × 6 inches. (Cambridge: At the University Press, 1917.) Price 21*s*. net.

Prof. D'Arcy Thompson has laid us all under a debt of gratitude in giving us this very fascinating book. Gathering a multitude of illustrative facts from many and varied sources, and adding many observations of his own, he has succeeded in showing us what promise there lies in the endeavour to apply the laws of physics and mathematical methods to the forms occurring in the organic world. The style in which it is written is both dignified and clear, and possesses a literary grace and charm which makes reading a pleasure though dealing with such an abstruse subject as the foundations of biophysics. "My sole purpose has been," the author says, "to correlate with mathematical statement and physical law certain of the simpler outward phenomena of organic growth and structure or form: while all the while regarding *ex hypothesi*, for the purposes of this correlation, the fabric of the organism as a material and mechanical configuration."

It was Galileo who nearly 300 years ago enunciated what is now known as the "principle of similitude," and the author treats this as a preliminary to a fine discussion on the Rate of Growth: dealing with growth in its relation to magnitude and to that relativity of magnitudes which constitutes form. "Rate of growth is subject to definite laws, and the velocities in different directions tend to maintain a *ratio* which is more or less constant for each specific organism; and to this regularity is due the fact that the form of the organism is in general regular and constant."

To the microscopist, however, the chief interest will be found to lie in the study of the conformation, within and without, of the individual cell; in the study of cell-aggregates and the forms of tissues. In these chapters (IV–VIII) the author shows how

intimately the outward form and the intra-cellular phenomena are related to physical laws such as those governing surface-tension and those forces which are in opposition to it. The account of mitosis is based on the provisional assumption that the phenomena are analogous to, if not identical with those of a bipolar electrical field. In the groupings of the daughter-cells in a segmenting egg as well as in the arrangement of the cell-boundaries in the meristem of an apical bud or developing sporangium, the author shows that the interpretation may be found in the principles which govern space-partitioning in minimal areas, and that we are but dealing with concrete instances of a subject, the theory of which has fascinated mathematicians since the days of Leibnitz and Euler. "Examples of these various arrangements meet us at every turn, and not only in cell-aggregates, but in various cases where non-rigid and semi-fluid partitions (or partitions that were so to begin with) meet together. And it is a necessary consequence of this physical phenomenon, and of the limited and very small number of possible arrangements, that we get similar appearances, capable of representation by the same diagram, in the most diverse fields of biology." In Chapter IX the spicular skeleton of sponges is dealt with, and a particularly interesting discussion on the conformation of the delicate and complex siliceous skeleton occurring amongst the Radiolaria, which have such a wonderful and unusual appearance of geometrical regularity. Prof. Dendy's presidential address to this Club on the "Chessman" spicules in the genus Latruncula and his paper in collaboration with Prof. Nicholson read at the Royal Society in June, on the ringed spicules of an allied genus, were published too late for reference by the author. The results obtained in this research show that the rings of silica are deposited at the nodes of a vibrating rod. Prof. D'Arcy Thompson would have seen in these results another instance of the advantages of mathematical methods. The general and mathematical properties of the logarithmic spiral are described, and the application of these to the spirals of molluscan shells, in a very attractive chapter, attractive not only for its matter but also for its beautiful illustrations.

The micro-biologist will, however, pass on to the treatment of the spiral shells of the Foraminifera. If the author's interpretation of the form and mode of growth of the foraminiferal shell be

accepted—and this applies with equal force to the Radiolaria referred to above—we shall be led to understand two striking features of these groups of Protozoa ; on the one hand, the very large number of diverse types or families and the large number of species and varieties within each, and on the other hand, the persistence of forms from very early periods to the present time. "In the order of physical and mathematical complexity there is no question of the sequence of historic time. The forces that bring about the sphere, the cylinder or the ellipsoid are the same yesterday and to-morrow. A snow-crystal is the same to-day as when the first snows fell. The physical forces which mould the forms of Orbulina, of Astrorhiza, of Lagena or of Nodosaria to-day were still the same, and for ought we have reason to believe the physical conditions under which they worked were not appreciably different, in that yesterday which we call the Cretaceous epoch ; or, for ought we know, throughout all that duration of time which is marked, but not measured, by the geological record."

The shapes of horns, of leaf-arrangement and phyllotaxis and the shapes of eggs are dealt with, and the book closes with a fine discussion, which is by no means the least interesting and important, on the Theory of Transformations or the Comparison of related forms. The comparison is made by means of Cartesian co-ordinates within which are inscribed the outlines of related organisms or their skulls.

In taking leave of this interesting and suggestive book, suggestive alike to the biologist and mathematician, we offer our congratulations to the author and to the syndics of the University Press on its production.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 523rd Ordinary Meeting of the Club, held on March 27th, 1917, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on February 27th were read and confirmed.

Mr. Thomas E. Wallis was balloted for and duly elected a member of the Club.

Before the regular business commenced, Past-President Professor Arthur Dendy—now Vice-President—said he had great pleasure in introducing to the members the new President, Dr. A. B. Rendle. It was scarcely necessary to do so, as his name would be quite well known to workers with the microscope, but personally he might not be known to some of the members; he himself estimated it a great privilege to welcome Dr. Rendle to the position. He was sure that if Dr. Rendle derived as much pleasure and profit as he had done from the meetings, he would be glad that he had accepted the post. He thought the Club was greatly to be congratulated on Dr. Rendle's consent to occupy it. In reply, Dr. Rendle thanked those present very heartily for the kind reception they had given him and for the honour they had done him by asking him to be President. Some might think his position as Keeper of Botany did not imply a great amount of association with the microscope. He might say that the first paper he had read was on a microscopical matter. It was on the structure of the seeds of the Lupin, and dealt especially with the development of the aleurone grains. His second paper was also on a subject which required the use of the microscope constantly for its determination. Although he might to some extent have departed from his first love, he did still use the instrument constantly, and that was a bond of union between

himself and the members, which he hoped would be cemented even more strongly, and he was sure that the time he spent with them would be a source of profit and pleasure to himself, and he hoped to them also.

The business of an Ordinary Meeting was then proceeded with. One new member was elected, and proposal forms for three others for consideration at the next meeting were read. Mr. W. Traviss exhibited a little apparatus he had designed, by means of which surface tension could be very effectively demonstrated under the microscope. It was a small cone, open at the top, which could be placed on the stage, and on a film of amyl acetate being stretched across the opening evaporation at once commenced, and under the microscope the currents set up in the film, and its gradual thinning away, could be watched till breakage occurred. Mr. A. E. Hilton showed under a microscope a specimen of *Trichia affinis*, one of the Mycetozoa. It was reputed common, he said, but he had not come across it yet in this country. The present specimen had come from Dublin. This species has a hygroscopic capillitium, consisting of elaters covered with spiral bands, which make them twist and move with any alteration in the moisture of the atmosphere. His chief interest in the study of the Mycetozoa was concerned with their bearing on problems of biology, and in that connection he was very glad that Dr. Rendle is the custodian of them at the British Museum. The President, in commenting on Mr. Hilton's remarks, said he was rather proud of having the group under his charge; they were neglected by the zoologists, and the botanists took them up.

Mr. C. D. Soar then gave a description of two new species of water mites, illustrated with lantern views of the entire specimens and of the minute details upon which the discrimination depends. One of the species had been found on Dartmoor, by Mr. G. T. Harris, to whom the Club was indebted for many interesting communications respecting his finds in that locality. Mr. Soar had named it *Dartia harrisii*, in honour of the place and of its discoverer. The other species belonged to the genus Eylais. Mr. Soar had given it the specific name of Wilsoni in honour of Mr. Wilson, who found four specimens at Staines at one of the Club's excursions. Besides describing the new species Mr. Soar at the same time gave a short history of the genus and showed how for many years only one species had been recorded, namely,

the type species *Eylais extendens* Mull., but with modern methods of preparation and mounting so many differences were recognised in various examples that the genus was now broken up into an immense number. The chairman said Mr. Soar was to be congratulated on having added two new species to our fauna, and joined with others in discussion on the subject of the address.

A paper by Mr. G. T. Harris, of Sidmouth, on "The Desmid Flora of Dartmoor" was then read (in part) by the Hon. Secretary. It began with a reference to previous records on the subject, and commented on their small number and the fewness of the species which were attributed to the locality. Mr. Harris then proceeded: "The section of Dartmoor dealt with in the present paper is the great central portion comprised between Cawsand Beacon on the northern extremity of the moor and Bellever Tor on the southern, with Metherall as its eastern boundary and Lydford as its western. This area is roughly a square of some one hundred and forty-four square miles, of unclaimed more or less trackless moorland." In collecting over this area it was divided into five districts for convenience. It would have been impossible to enumerate the species of each pool separately, so the plan of grouping the bogs and pools into their respective districts was adopted. Collections were made during July, August, September and October in 1915 and 1916. The extent to which desmids are devoured by various aquatic animals was noticed, and some remarkable instances recorded. In one individual of a species of Euclanis no less than twelve desmids were seen, and in another case a rotifer had ingested seven. In the field each collection was kept separate and duly labelled. Unimportant stations might yield from seventy to eighty records, average-sized bogs 120 to 130, while from more extensive and ancient bogs 230 species would be recorded. Tables with the records of the various districts were carefully kept, and, with plates illustrating a number of the more remarkable forms, will appear in the next number of the *Journal* of the Club. The nomenclature followed in the paper is that adopted by W. and G. S. West in their monograph of the British Desmidiaceae, as far as it is published. In closing, Mr. Harris tendered his thanks to those who had assisted him in the task of identification of his finds, most of whom are members of the Quekett Microscopical Club. There was some discussion

at the close of the paper, and many of those present bore testimony to the interesting and valuable character of the communication. Mr. Bryce said that he had spent some time with Mr. Harris, and was much struck with the richness of the neighbourhood in all kinds of life. He had found his time quite taken up with the Rotifera (his own special field), of which there was abundance. Mr. J. Wilson, one of those mentioned by Mr. Harris, said those who had not experienced it could hardly realise the tremendous amount of work entailed by such a paper. He had great pleasure in proposing a hearty vote of thanks to the writer. This was seconded and duly carried.

At the 524th Ordinary Meeting of the Club, held on April 24th, 1917, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on March 27th were read and confirmed.

Messrs. Charles H. Smith, Charles F. Sonntag, and William R. Chapple were balloted for, and duly elected members of the Club.

Dr. J. Rudd Leeson, F.R.M.S., then gave a lecture "On the House Fly, *Musca domestica*, with Special Reference to its Danger to Health." This was illustrated by sixty lantern slides, and a selection of preparations which were exhibited under microscopes on the table. In his address which accompanied the lantern views Dr. Leeson said: "It was not till 1882 that flies were known to be the bearers of disease—then malaria was traced to the mosquito. Nothing was known about the house fly in relation to disease till 1905. Of all creatures it is the one most commonly associated with man—everywhere, from the Polar regions to the Tropics. It is now known to be the carrier of the microbes of anthrax, infantile diarrhœa, cholera (10,000 colonies were obtained from one fly), typhoid (the microbes have been found in its intestines twenty-three days after ingestion), ophthalmia, tuberculosis, diphtheria, pneumonia, etc. A house fly was allowed to walk over a plate of sterilised gelatine and a few hours later 46,000,000 germs of typhoid, diphtheria, tubercle and pneumonia were counted."

Of 414 flies examined, the average number of pathogenic organisms upon each was a million. The fly has therefore been

unmasked by science as one of man's greatest enemies. It has no true teeth, but obtains its food by suction. This passes into the crop and subsequently overflows into the true stomach. When the fly alights on any solid substance, such as sugar or cold meat, it vomits the contents of its crop upon it to soften the material, which it contaminates to our cost. House flies will vomit fifteen times an hour and defecate ten times; these habits constitute their supreme danger to mankind. The average of many fly censuses taken in England and America gives the different species of house flies the following percentage: Common house fly, 82 per cent.; lesser house fly, 14 per cent.; stable fly, 1 per cent.; blow fly, 1 per cent.; other species, 2 per cent. The wings move with great velocity: in flying they make 330 complete strokes in a second. Nearly the entire thorax is filled with the muscles connected with the wings, but the tracheal or respiratory system occupies more space than any other; this makes the creature very buoyant. Under the back of the wings are two drumstick-shaped appendages known as halteres, which are very characteristic of the Diptera. Their purpose is not certainly known, but they are supplied with, next to the optic nerve, the largest nerve in the body. The mechanism of the proboscis was explained; the long salivary glands and the intestinal system described. The eyes, with their 4,000 lenses, and the three ocelli on the top of the head referred to. Each of the ovaries contains about 75 eggs in various stages of development; 150 are laid from four to six times in the life of the fly, but the blow fly lays 1,000 each time. The immense number of flies that one pair would produce in a season, if all the progeny survived, was mentioned, one authority putting it at 500,000,000. The time taken by the fly in passing through its life circle was spoken of; it depends greatly upon the temperature and general conditions, but in the summer may be accomplished in about ten days. Its ordinary life lasts about seven weeks. "Fortunately, flies have their enemies: thread worms discomfort them from within, and the fungus *Empusa muscae* attacks them from without with deadly effect. Mites worry them, beetles devour their larvae, and wasps, robber flies, spiders, centipedes, ants, lizards and birds all take their toll. One of the most unfortunate parts of their anatomy is the innumerable hairs with which their bodies

are covered, each bearing its thousands of micro-organisms." The desirability of killing as many as possible, especially in the spring before they have had time to breed, was insisted upon, and steps which should be taken to this end were described. One efficacious method is: "Keep a soup-plate with a piece of bread, upon which the flies can alight to drink, nearly covered with sweetened milk and water, in which is mixed a teaspoonful of formalin, all other liquids being removed. In the early morning the flies will take their fatal draught." Protect all food with wire gauze or muslin, particular care being taken in cases where there is sickness in the house. All the principal points of structure referred to in the lecture were illustrated on the screen, and figures of the various species of flies other than the common house fly were shown and brief directions given for their recognition. Several of those present asked Dr. Leeson questions on various details, and at the conclusion of considerable discussion the President expressed the thanks of the meeting to him for his extremely useful lecture, the vote of thanks being confirmed by acclamation.

At the 525th Ordinary Meeting of the Club, held on May 22nd, 1917, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on April 24th were read and confirmed.

Messrs. F. Browning, Chas. Ed. Hearson, W. T. P. Cunningham and F. Melhuish were balloted for, and duly elected members of the Club.

Six names were read out as candidates for election at the next meeting. Before the commencement of the usual business the chairman said the members would be sorry to hear of the death of Mr. Alpheus Smith. As most of them would remember, he had been hon. librarian of the Club, and had held the office for forty years. He was eighty-seven years of age. The announcement was received by those present standing as a mark of respect, and the Hon. Secretary was directed to write a letter of sympathy and condolence to the family of Mr. Smith.

Dr. J. Rudd Leeson gave a short description of a series of four micro-preparations from the house fly. These were exhibited under microscopes on the table, and consisted of the ovipositor,

the eye, the head showing the brain and a mount showing what Dr. Leeson considered to be a sense organ. This was found on the coxa; it was an oval organ, with six or seven white spots upon it, each bearing two hairs. He had not been able to find a notice of it in any book, although it was a very singular and definite structure. A hearty vote of thanks was accorded to Dr. Leeson.

The President then gave an address on "Colour in Plants and its Preservation." The following is a condensed report of the paper. It was stated that the object of the communication was to show some of the results of attempts to preserve the colour of plants in specimens destined for exhibition and to indicate some methods with their possibilities and limitations. But it would be helpful, first, to consider the substances with which it would be necessary to deal. The colour of an object depends on the quality of the rays of light which it reflects to the eye. If no light is reflected it will appear black; if all the rays which make up white light are reflected it appears white; and if only a portion of the rays are reflected—others being absorbed—it will have the colour corresponding to the rays which are reflected. Colour in plants is due to the presence of solid bodies or solutions, which exercise a selective power on the rays of white light which fall upon them. The solid bodies are specialised portions of the protoplasm; at first white. On exposure to light they develop a green pigment, chlorophyll, and are known as chloroplasts. Later, by the formation of new pigments, they may become yellow, orange or red, when they are known as chromoplasts. The most important and widespread, however, is the chloroplast, which gives the green colour to the leaves and young parts of the higher plants, and to the plant body, or thallus, of the lower plants, algae and liverworts. In the brown and red seaweeds it is masked by the presence of other colouring matters. The green colour may be extracted by alcohol. If the crude extract be shaken up with benzene, a blue-green dye is dissolved out, leaving behind a yellow dye. Chlorophyll is an exceedingly complicated substance, in the composition of which lecithins and possibly proteid compounds take part. Most yellow, orange-yellow and orange-red flowers owe their colour to chromoplasts. The pigment may be uniformly distributed, but generally occurs as small amorphous

granules or crystals. The crystals are carotin, so called because first isolated from the root of the carrot. It occurs in some flowers and in fruits, as the tomato. The most widespread pigment in chromoplasts is yellow or yellow-orange. It is known as xanthin. Nearly all yellow flowers owe their colour to it.

The soluble pigments exist in solution in the cell-sap. The most important and interesting is the series of anthocyanins, to which are due most of the reds and blues, and combinations of these in purples, violets, etc. They are almost universally distributed, and occur normally, or as the result of unusual conditions. Anthocyanin is often associated with damp- and shade-loving plants, and is developed specially on the under surface of leaves. The leaves of water-lilies and other aquatics are often light green above and deep violet below. The variegated plants of cultivation—Caladium, Dracaena, Coleus, Begonia, etc.—were also referred to. The autumnal coloration of leaves is due to anthocyanin. Low temperatures may induce its formation, and it occurs in Arctic plants and in many evergreen shrubs and herbs during winter. The colour of copper beech and similar varieties is due to its presence. Chemically, the anthocyanins are a class of substances, somewhat allied to sugars, known as glucosides. They are soluble in water and generally in alcohol, and may be obtained in the crystalline form. They give a bright red colour when treated with acids, and generally green with alkalies. A great deal of interesting work has been done and much has been written on the relation of these substances to the process of photosynthesis, to the effect of temperature, light, drought, presence of oxygen, excess of sugar in the tissues and to other conditions and factors. Their physiological significance has been much debated, two rival views having been advocated: first, the "light screen" hypothesis; secondly, the "heating" hypothesis of Stahl. A fair number of flowers owe their colour to another series of soluble pigments, the xantheic series, which are yellow, orange-yellow or red. They occur in primrose, yellow rose, narcissus, eschscholtzia and others. The colour of a flower is frequently a combination of effects, usually of an anthocyanin in the epidermis overlying cells containing chromoplasts; where blue anthocyanin overlies yellow chromoplasts, green is formed, as at the base of the yellow petals in some tulips.

The process of treating the green parts of plants, notably flowering plants, with a solution of copper acetate dissolved in strong acetic acid was proposed by Prof. Trail, and his directions for using a hot solution are now recognised as generally the best method. The object of the process is to form permanent green compounds of chlorophyll and copper. The fresher the plant the more successful will be the treatment. In spring, when the leaves are young and active, the result is better than in autumn. Deciduous-leaved plants, as a rule, green quickly and well, while evergreens require protracted boiling, some changing to brown at first, but after twenty to forty minutes' boiling this gradually gives way to green. Glass or porcelain vessels should be used for treating specimens with the boiling solution. Drying after the process may be by pressure in drying paper or in hot sand, the choice depending on the texture of the plant.

Dr. Rendle exhibited a large number of specimens of various plants preserved by the method he had described. Some ferns were particularly beautiful, the vivid green colour giving them an extremely natural appearance. Liverworts, mosses and selaginellas all retained a most life-like aspect. Specimens of red seaweeds which had been permanently stained to represent the natural colour were also shown; and several specimens of flowers which had been dried in hot sand or the Fothergill press, notably a delphinium and a scarlet geranium, in which the brilliant colours seemed altogether unchanged by the process of drying, in some cases after an interval of many years ago.

Mr. N. E. Brown then showed a number of dried herbarium specimens, in most of which the colour was excellently kept, although they had been prepared many years ago. He said that it was evident that the means which proved successful in one case might not answer in another, but he had found that the best method was to carry through the drying process as quickly as possible, and that it should be done at a somewhat high temperature.

Mr. F. J. Perks said he was sure the members would wish to accord a hearty vote of thanks to the President for his interesting and valuable address and for the trouble he had taken in bringing the very beautiful specimens to the meeting. The proposal was agreed to by acclamation.

At the 526th Ordinary Meeting of the Club, held on June 26th, the President, Dr. A. B. Rendle, F.R.S., in the chair, the minutes of the meeting held on May 22nd were read and confirmed.

Messrs. Rob. H. Thomas, W. T. Waller, Henry Williams, Stanley Lindwall, Joseph Edgar and J. Goodhart Evans were balloted for, and duly elected members of the Club.

The appointment of Mr. Frederic J. Cheshire—a member of the Club—as head of the new Department at the Imperial College, with the title Director of Technical Optics and Professor of Technical Optics at the Imperial College, was referred to by the chairman.

Mr. Burton called attention to an exhibit under a microscope on the table, which appeared like a cellular membrane, the cells more or less hexagonal in shape. He said at the Club's excursion to Ealing the surface of one of the ponds was to a large extent covered with a thick green scum, which also spread over grasses and various objects floating on the water. This proved to be *Euglena viridis* in an encysted state. When conditions were favourable the euglenae often rose to the surface, and there became encysted, each individual assuming a spherical form and surrounding itself with a firm cell-wall. When very numerous, owing to pressure the cells become hexagonal, or distorted, and adhering together, form a kind of skin or pellicle; it was an instance of this which caused the appearance noticed at Ealing. After a time division into two (or sometimes four) takes place in most of the individuals, which then emerge, leaving the empty and colourless cells floating. As they have some amount of cohesion they may continue as a thin pellicle for a time. It has been mistaken for an alga, and was described as such. By careful management portions may be brought away, and can then be mounted as a permanent object.

Mr. N. E. Brown, A.L.S., then gave an address on "Evolution as Illustrated by a Genus of Plants." He passed round a small flower-pot, which contained four very singular-looking plants; they were cone-shaped, with the apex downwards, of various sizes up to about 1½ in. high, and each had a small orifice resembling a closed mouth at the top. He said: "Each of the specimens is a distinct species, and, although very small, each is a full-grown adult individual that has reached the flowering stage, and although each will branch and ultimately form a small

clump, the individuals of that clump will not be very much larger or smaller than those before you." Attention was directed to the small closed orifice at the top, resembling a tiny mouth with closed lips. They were rare plants, three of them undescribed and unnamed species at present. The audience were invited to give the name of the genus, or even of the order to which they belonged, if able, but no one seemed inclined to attempt this. Mr. Brown was not surprised, and remarked that "when the first species of this group was described and figured in 1738, its discoverer, Johannes Burmann, Professor of Botany at Amsterdam, mistook it for one of the puff-ball fungi." Mr. Brown said he wished to show some of the stages that seemed clearly to indicate the connection of the simple forms seen in the pot before them with other forms that appear to have no resemblance whatever to these. "The divergence of the species of this genus is very great and remarkable. To start with, we have humble and simple plants like those shown, and radiating from them as an initial stage are many lines of development—one line culminating in a shrub 15 ft. high, another ending in a herb with a loose tuft of a few erect leaves as large as those of a lettuce, and trailing flowering stems two or three feet long and an inch thick. Yet the flowers throughout the genus vary very little except in size and colour. The genus is Mesembryanthemum, commonly called ice-plants. This particular group of the genus is one of the most remarkable at present living, and has two special points of interest:—(1) With the exception of the members of the order Rafflesiaceae, in their vegetative organs they are the most primitive and simple of all Dicotyledons, and quite unlike any others in existence; (2) the peculiar manner of their growth, which seems utterly unlike that of any others, and yet, when critically examined, is found to follow the same general rule as other flowering plants. It is a recognised fact that, however widely adult organisms may differ, yet in their embryonic stage they are often similar. We note that when we sow seeds belonging to a great variety of plants belonging to different orders, when the seedlings first appear there is often a great similarity in their form." This is the case in the seedling stage of Mesembryanthemum, but in the group to which those shown in the pot belong, the seedlings are reduced to the most primitive condition possible. "In most cases, as the plant

develops, it assumes quite a different form from that of the seedling stage, but some members of this group only depart from the embryonic form to a slight extent during the whole of their life. Therefore we may fairly consider this group to represent the primitive stages from which the more complicated members of the genus have step by step developed." Instances were given here, and sketches illustrating the various stages were drawn upon the blackboard, making the matter very clear and definite to those present. Mr. Brown remarked that, before proceeding to trace a connection from species to species, it is necessary to understand the structure of the plants. In this connection he said: "If a transverse section of the body is made, it is found to consist of an elliptically shaped slice of soft, watery tissue, with a small, narrow, slit-like cavity at its centre, corresponding to the orifice at the top." A flattened tubular canal extends from the orifice almost to the base of the plant, where, at the right season, either a young flower-bud or a young vegetative bud will be found. If a flower, it will ultimately grow up, push through the orifice, and expand. At the base of the flower-stalk, inside the plant, one or two vegetative buds form. At the very base of each plant the tissue becomes firmer, sometimes more or less woody, finally assuming the character of an extremely short, or more or less elongated stem, according to the species. The solid-looking body of the plant is really formed of two opposite fleshy leaves, united to each other, with the exception of the canal which runs down the centre. All the specimens in the pot passed round were constructed in this way, so that each is stemless, or nearly so, and consists of a pair of simple fleshy leaves united into a single obconic or globose body, thus representing a very primitive type of plant so far as the vegetative organs are concerned, whilst the flowers are of a highly complicated structure. The manner of growth is remarkable. During the summer the vegetative buds in the interior, at the bottom of the canal, gradually develop, and as they enlarge the water and food material stored up in the fleshy leaves is gradually absorbed, so that the visible part appears as if the plant is dying, and at length becomes a mere dry, crumpled skin, concealing the young growth, which ultimately bursts through.

"In tracing the gradual evolution of the more complex forms

from the simple ones, the first change noted is that in some species there is a slight depression across the top, by which the apices of the combined leaves on each side of the orifice slightly overtop the latter. In another species the depression is more pronounced: in another it becomes a distinct notch; in another the notch is deeper and the plant is two-lobed. These are all indications of the progressive separation of the two leaves of which each plant is composed. In different species the separation becomes more and more apparent, until we find forms in which the two leaves are separated nearly or quite, to their base. This progression will only result in the plant having but two perfectly developed leaves, besides the withered remains of the old ones, at the same time. Other species, however, will show a tendency to develop a new pair of leaves before the old pair have begun to shrivel, and from such forms the transition is easy to such as normally have two pairs always present, and from these to others having three or four pairs present on each growth, forming a tuft. The passage of this type to that with several or many leaves in a rosette is exhibited by many species. Such a progressive change, although finally leading to several different types of modification, is produced without any great development of the stem. But the development of the shrubby forms from these can also be traced. Several of the primitive species with age gradually develop short stems and branches, which, becoming covered with earth, are more or less subterranean. Some, however, gradually develop short stems above the ground. From such types a passage to another and distinctly shrubby form is arrived at by the internodes developing in varying degree according to the species. Finally, you may have a shrub 15 ft. high, formed by the superposition of one segment on another, each having a short woody stem (internode) at the base. I am not mentioning their specific names, because most of the plants shown are new species, and have not yet been named. It is not possible to show all the stages of connection, as that would require a greater number of specimens than could be brought together, but examination will, without showing every link in the chain, make sufficiently clear the manner in which the lines of development have progressed, by a slight modification here, and another there, until a totally different type has become evolved."

Reference to a large number of living plants and blossoms,

which were exhibited at the meeting, as well as some beautiful drawings, and also sketches on the blackboard, proved and emphasised the various points Mr. Brown gave in his lecture. At its close several of the audience raised questions of interest and joined in a discussion on the subject. The President, in moving a vote of thanks for the lecture, said: "We have heard the result of original, careful and laborious investigation, and we feel highly complimented that Mr. Brown has brought so much of the fruit of his work on these plants before us, and explained it so lucidly."

OBITUARY NOTICES.

ROBERT BRAITHWAITE, M.D., M.R.C.S., F.L.S., F.R.M.S.

May 10th, 1824—*October 20th*, 1917.

It is with much regret we have to announce the death of Dr. Braithwaite in his ninety-fourth year; he was the eldest son of Robert Braithwaite, shipowner of Ruswarp, near Whitby, where he was born in 1824. He was educated at the Grammar School at Whitby and afterwards studied medicine, becoming M.R.C.S. in 1858 and M.D. of St. Andrews in 1865. He married the daughter of Dr. N. B. Ward, F.R.S., the inventor of the Wardian case and a botanist of repute, who was then practising at Clapham. Dr. Braithwaite succeeded to the practice, which he carried on for many years in Ward's old house, "The Ferns," 303 Clapham Road. About twenty years ago the house, like many others on the main roads near London, was demolished, and red-brick flats now occupy the site. His leisure time was devoted to the study of the Moss Flora of his country and of Europe generally, and in this subject he became the greatest authority.

He was elected a member of the Q.M.C. in the year of its foundation, and in the following year (1866) became F.R.M.S. He was President of the Club during the years 1872–74, and in that period delivered six lectures on the Histology of Plants which appear in the First Series of the *Journal* (Vol. III.) and are illustrated with drawings from his skilful pencil. A very interesting contribution to the *Journal Q.M.C.* was read in January 1870 on *The Geographical Distribution of Mosses in Europe.* This paper forms an early ecological study of moss-groups.

Dr. Braithwaite joined the Linnean Society in February 1863, and was one of the longest-standing members. He served on the Council 1872–74 and 1889–92, and was a Vice-President 1889–91.

Alpheus Smith.

Adlard & Son & West Newman, Ltd.

Dr. Braithwaite's *magnum opus* is *The British Moss Flora*, the publication of which was completed in 1905 in three large octavo volumes and constitutes the standard work upon this subject. The 128 plates were engraved from drawings made by the author, and the whole work forms a remarkable monument of his great skill and industry. In addition Dr. Braithwaite published a monograph on the Peat Mosses: *The Sphagnaceae or Peat Mosses of Europe and North America.*

Dr. Braithwaite's very large collection of *separata* relating to the Musci is now in the Library of the Royal Microscopical Society. They together form ten volumes, and are indexed in the First Supplement (1910) to the Library Catalogue.

His herbarium of British Mosses, which is authoritative for his work *The British Moss Flora*, was purchased a few years ago by the Trustees of the British Museum, and is available for consultation in the Department of Botany.

ALPHEUS SMITH.

1830—1917.

It is with much regret we have to record the death of Mr. Alpheus Smith, which took place at his residence in Streatham on May 16th. Mr. Smith joined the Club on May 25th, 1866, and for over forty years served the Club in the office of Honorary Librarian. He was born at Arundel in 1830, and was educated at Guildford, and for forty-seven years was the trusted employé of a firm of leather merchants. Mr. Smith was a member of the Library Association of Great Britain and a well-known figure at their annual congresses.

As Librarian of the Club he was well known to many of our members, who much appreciated his courteous manner and unfailing helpfulness. Although his interest in microscopy was but slight, he found in the duties he had undertaken and performed for so many years a source of much pleasure. He was elected an honorary member of the Club in 1912, and his last appearance at a meeting of the Club was on the occasion of the fiftieth anniversary.

The portrait of Mr. Smith is from a recent photograph.

THE PRESIDENT'S ADDRESS.

THE USE OF MICROSCOPICAL CHARACTERS IN THE SYSTEMATIC STUDY OF THE HIGHER PLANTS.

By A. B. Rendle, M.A., D.Sc., F.R.S.
Keeper of Botany, British Museum (Natural History).

(Delivered February 12th, 1918.)

The study of microscopic organisms is one in which members of the Quekett Club are so well versed that it is unnecessary to refer to the value of the microscope in the systematic discrimination of their families, genera and species; many of the objects of your study are recognisable only under a fairly high power. Even in those groups of the lower plants where the individual attains a considerable size the characters which are regarded as of value for the determination of its systematic position enjoin the use of the microscope. Seaweeds cannot be studied apart from the microscope; and the determination even of the larger Fungi becomes merely a question of matching unless minute characters, such as those associated with the spore, are studied.

You cannot get very far in the study of Lichens without the microscopic examination of a section; and the description of a genus, or even of a species, is not now considered complete without reference to the number, shape, size or special characters of the spores.

In the study of Mosses "the cells of which the lamina of the leaf consists furnish characters of the greatest importance both on account of the ease with which they can be observed and their high degree of constancy"—to quote the author of that excellent guide to the study of British mosses, Mr. H. G. Jameson.

The Ferns are eminently macroscopic plants, but an examination of the frond does not carry us far, and even for the recognition of the larger groups an examination of the structure of the sporangia is necessary.

In the highest groups, those comprising the Flowering or Seed Plants, the development of an inflorescence, flower, fruit and seed, has supplied macroscopic characters on which our system of classification has been based. But there is an increasing tendency to use minute characters as supplementary to or in conjunction with the macroscopic; and in the case of limited material the study of minute characters becomes of the greatest value. In the study of fossil plants, where the material consists often of specimens showing only stem-structure, the worker has to depend entirely on his microscope for their systematic elucidation. I need not remind you of the large amount of recent work in this branch of botany in which the diagnosis of specimens depends entirely on internal structure as revealed by the microscope, or of the great value of the results obtained as bearing on the phylogeny of the higher plants. I do not propose to go into this in detail. In modern flowering plants there is also considerable variety in the details of the stem-structure as revealed by the examination of a section under the microscope, and indications of the systematic position of the plant in question may be obtained by this means; but there is room for a much more extensive and careful study on these lines.

The earlier group of the Flowering Plants, the Gymnosperms, by far the greater number of which are included in the Coniferae (pines, firs, etc.) are distinguished from the later group, the Angiosperms, which includes the great majority of modern trees, shrubs and herbs, by a remarkable uniformity in the structure of the secondary wood. This is due mainly to the absence, as seen in cross-section, of the larger openings which represent the vessels, which are a characteristic feature of the secondary wood of Angiosperms. Among the conifers the wood of the yew shows the greatest uniformity, as it consists of one kind of tissue only, tracheides, the regular arrangement of which is unbroken by the thinner-walled cells (parenchyma) which accompany the tracheides in other conifers, and by the resin-canals which frequently occur running longitudinally between the elements, as in pines, firs, larch and others. Here, there are minute characters which enable us to determine even small fragments of wood as coniferous, and among these to discriminate yew. The systematic determination of plants by characters supplied by the wood is a matter not merely of academic interest. Valuable information

on the nature of the past flora of a region may be gained in this way, from the examination of long-buried fragments of wood. The antiquarian or ethnologist frequently wishes to know the nature of the wood of which some article of interest to himself is made. And the bore will invite you to diagnose the botanical nature of his walking-stick. If time is precious the last-named may generally be choked-off by suggesting the necessity of cutting a cross-section.

A case which frequently recurs is the discrimination between oak and chestnut in connection with the timber-work of old buildings. The trees themselves are so distinct in habit, and in character of leaf, flower and fruit, that it may be a little surprising that there should be a difficulty in distinguishing the two timbers. The component parts of the wood are, however, similar in the two species; and though what we call a typical piece of oak is distinguished without difficulty from a typical piece of chestnut, there are certain varieties of oak which so closely approach chestnut as to give rise to considerable difference of opinion among experts as to the nature of the wood.

You may remember a controversy a few years ago, when the roof of Westminster Hall was undergoing repair, as to whether the original structure was oak or chestnut. There was difference of opinion among experts, but the view which was ultimately accepted, I think rightly, was that the structure is oak. I have recently been asked to give an opinion as to the nature of the wood used for the roof of the hall at Winchester School. Tradition calls it chestnut, but microscopic examination leads to the conclusion that it is oak. The nature of the thin layers of wood used in the construction of the propellers of the Zeppelins which were brought down near London supplied problems which were of interest to us at the Museum, and were also, I believe, of some importance to those in authority.

The microscopic study of timber-structure is of considerable importance commercially. Timber is put on the market under some name known in the trade, and the assumption is that the sample will have the properties of tensility, rigidity, durability, etc., which are associated with that name. These properties, or their proper combination, may be of vital importance in connection with the use to which the timber is to be put. For instance in the manufacture of an aeroplane an insufficiency in one respect

may cause disaster. But in timber from allied species, there may be a close general resemblance associated with important specific differences which are recognisable only by a microscopic study of the minute structure. We are beginning to appreciate the importance of an intensive study and a careful photomicrographic record of the minute structure of the timber of species of economic value.

The forests of tropical Africa are rich in a great variety of hard woods. Much of the so-called African mahogany which is put on the market is the product of trees the genera and species of which are not adequately known. The original Honduras mahogany is the product of a Central American species, *Swietenia mahogani*, the African woods belong to other genera of the same family, Meliaceae, and there is need for a careful systematic study of their species, as embodied in the characters of foliage and flower, in association with the study of the minute structure of the wood. The microscopist in association with the systematist can do work of great importance.

I have referred to the simplicity of the secondary wood in the Gymnosperms as contrasted with the variety of elements of which it is composed in woody Dicotyledons. The most striking distinction between these groups is the absence in the former of that definite aggregation of sepals, petals, stamens and carpels which we call a flower and the remarkable development and variety of which is such a characteristic feature of the Dicotyledons. A small family of the Gymnosperms, the Gnetaceae, is exceptional in having a wood-structure similar to that of the Dicotyledons, and also an arrangement which is somewhat suggestive of the flower of certain Dicotyledons with a very simple type of flower. The question arises whether this resemblance is an indication of relationship, and an attempt has been made to trace the ancestry of the Dicotyledons back through this group. But the three genera which are associated in the family Gnetaceae are plants highly specialised for life under somewhat peculiar conditions—one is a tropical woody climber, the others are adapted for growth in desert areas—and one hesitates to draw far-reaching conclusions on relationship from such specially adapted organisms. We bear in mind the remarkable differences in habit and vegetative structure of species even in the same genus where they are adapted to different conditions of life.

The wood of the Dicotyledons contains, besides the tracheides, vessels, recognised in the transverse section by larger openings, thick-walled fibres of various kinds and shorter regular-shaped elements or parenchyma. The considerable variety of combinations of these elements which is possible accounts for the variety in appearance to the naked eye, but more especially under the microscope, of the wood of dicotyledonous plants. Closely allied species generally show a resemblance in the structure of their wood, and certain characters are often common to genera or groups of genera; but on the other hand, genera which from every other consideration are regarded as occupying widely removed positions systematically, may be closely alike in the structure of the wood. A striking example occurs in the wood of *Drimys*, a species of which supplies the drug known as Winter's Bark,* which in its remarkable uniformity of structure resembles the yew. This resemblance has been used in support of the view that the Magnolia family, to which *Drimys* belongs, comes very early in the scale of development of the Dicotyledons and approaches most nearly the Gymnosperm ancestor from which the Dicotyledons may be presumed to have been derived.

But in view of the fact that the wood-structure in the Magnolia family belongs otherwise to a type which is one of the commonest among the Dicotyledons, one hesitates to use an isolated instance to support so far-reaching a conclusion in phylogeny. At present we can only say that we know too little as to the meaning of these variations in the character of the minute structure of wood, and as to how far they are expressions of relationship or the results of comparatively recent adaptation to environment. But I think I have said enough to show that the microscopist has here a wide field of investigation and an opportunity for work not only of purely scientific but of great economic value.

An anatomical character which is of value for systematic purposes is the presence and character of the receptacles containing secretions of various kinds. The secretion may be contained in epidermal outgrowths of the nature of hairs, the structure of which may be more less characteristic of certain families or genera, as in *Primula*, *Pelargonium* (the Geranium of gardens), and many members of the Dead-nettle family which owe their

* This bark was first brought to Europe in 1579, by Captain Winter, who accompanied Sir Francis Drake to the Straits of Magellan.

characteristic odour to the secretion which is developed in the hair-cell between the cuticle and the outer wall, the secretion being set free by rupture of the cuticle.

In the interior of the tissue the secretion may be formed within special cells, which may be very long and often branched, as those which contain the milky juice or latex in the spurges and other members of the Euphorbia family, or may consist of short elements placed end to end and perforated, forming vessels, as in the latex-containing tissue of dandelion, chicory and other members of the family Compositae; or canals may be formed by the separation of rows of cells, leaving a long narrow intercellular space, as in the resin-containing canals of coniferous plants. There is a remarkable external resemblance in the habit of the cactus-like Euphorbias, which are a feature of the arid districts of tropical Africa, and the Cacti which are associated with similar conditions in the deserts of the Southern United States of America. But the presence of the latex-containing cells of the Euphorbias supplies a distinctive anatomical character. The number and position of the resin-canals which are found in the stem and leaves of many conifers are useful characters in the distinction of the species.

Many of these secretions are, from the point of view of the plant, of the nature of waste-products. Owing to the fact that plants do not perspire and have no kidneys, other ways of getting rid of waste-products of metabolism have to be devised. These products are set aside outside the sphere of metabolic activity, as in the secretory vessels already mentioned, or are deposited in the bark which becomes gradually exfoliated, or in the leaves which are ultimately thrown off. An interesting example, which also affords characters of use to the systematist, is found in the Cystoliths. These consist of local growths of the cellulose cell-wall which become permeated with minute particles of carbonate of lime. If treated under the microscope with a dilute acid the carbonate is dissolved and decomposed, and we may watch the tiny bubbles of carbonic acid gas which are given off in the process. The matrix remains as a delicate cellulose skeleton showing well-marked stratification. Cystoliths are very common in two widely separated families, Urticaceae (the nettle family) and Acanthaceae. They were noticed in the former by Meyen in 1839 in the leaf of the well-known India-rubber plant, *Ficus elastica*. They occur generally in the large genus *Ficus* (the figs), varying in form and

size in different species; and also in other genera of the family; and their relative frequency and form often afford useful specific characters. The upper surface of the adult leaf is often rough from the presence of the numerous cystoliths which occur as small dots, or shorter or longer lines, or they may be curved.

In the family Acanthaceae also the form varies in different genera and species.

I should exceed the time at my disposal, and weary you into the bargain, if I went into the subject of plant-hairs—a beautiful and interesting microscopic study. As regards their distribution from the point of view of the systematist I may quote the apt remark of De Bary, that the case is similar to that of the forms of foliage-leaves. On the one hand there is great uniformity in the majority of species and genera of one family, at least as regards one characteristic form of hair, such as for instance the stiff hairs of the Borage family, the short capitate hairs and scales of the Dead-nettle family, the star-shaped hairs of the Crucifers, the tufted hairs of the Mallows and the three characteristic forms of hair of most of the Hawkweeds. On the other hand, a great variety of form may occur in the same family or even genus; or one characteristic form recurs in corresponding parts in the most diverse families or genera, such as the stinging-hairs of the nettle-family and of the widely removed family Loasaceae.

So far I have dealt with vegetative structure only, but the special organs of the flower also supply minute characters which are useful for systematic purposes. I will refer briefly to one only, viz. the characters of the pollen-grain. To some extent these are obviously adaptive. In a few submerged aquatic plants, pollination, the transfer of the pollen from the stamen to the stigma of the ovary occurs beneath the surface of the water, and in these cases the pollen sometimes takes the form of long threads.

In many plants the pollen is distributed by aid of air-currents, and here the grains are very small and smooth, like fine dust, and do not cling closely together; in the pine the outer skin is blown out to form a pair of air-bladders.

In flowers in which the pollen is transferred on some part of the body of an insect which has visited the flower in search of honey or pollen, the grains are sticky and cling together in small masses. In these cases there is an extraordinary variety of form and external sculpturing of the grain, as to the meaning

of which we know little or nothing, and which might well form the subject of a separate address. A certain form may be characteristic of a family, as for instance the spiny pollen of the Mallows; or, on the other hand, a remarkable variety may occur in one and the same family, as for instance in the Acanthaceae, where the different genera show remarkably varied and characteristic pollen-forms.

In the family Convolvulaceae the character of the pollen affords a ready means of distinguishing genera that are otherwise closely similar in characters of foliage, flower and fruit. Thus the genus *Ipomoea*, the convolvulus of the tropics, which includes the Morning Glory and the so-called "Convolvulus major" of gardens, has spiny pollen resembling that of the Mallows, whereas in the genus *Convolvulus*, which includes our common bindweed, the pollen is smooth. The series of lantern slides which follows shows on the one hand a striking resemblance between the pollen of genera of the same family, and on the other hand that there is often a remarkable difference between the pollen-grains of allied genera; the case of the cornflower in the Compositae is an interesting illustration of the latter.

In conclusion, it is obvious that the systematist may derive great help from the study of minute characters, but it is equally obvious that single characters must be used with caution, and this warning applies not merely to those which can be elucidated only by use of the microscope.

I should add that a large proportion of the lantern slides by which I have been able to illustrate my address have been lent me by my friend Dr. Rodman, our fellow-member, whose skill and zeal in photomicrographic matters is well known to you.

ON *SCHISTOSTEGA OSMUNDACEA* MOHR.

By G. T. Harris.

(*Read March* 12*th*, 1918; *communicated by the Hon. Editor.*)

Plates 23 and 24, and Figures 1–3 in Text.

This moss was originally described and figured by Dickson in 1785 (**1**), and named by him *Mnium osmundaceum*. Later, in 1803, Mohr instituted the genus *Schistostega* for it, restoring Dickson's specific name of *osmundacea* which had been superseded by Ehrart and by Hedwig (**2**). Sir J. E. Smith in his great work on English plants (**3**) followed Hoffmann's lead of placing it in Hedwig's genus *Gymnostomum*, presumably on account of its gymnostomous capsule. Hooker and Taylor (**4**) accepted Mohr's genus but adopted Hertwig's specific name of *pennatum*. Bridel (**5**), Bruch and Schimper and Gümbel (**6**), Wilson (**7**) and Berkeley (**8**) all adopted Mohr's nomenclature, and as Braithwaite (**9**) and Dixon (**10**) among modern bryologists confirm these previous authors by themselves accepting Mohr's genus it may be taken that finality has at length been reached.

It is the only species of its genus and order.

The plant upon which Dickson's original description was based was collected in Devonshire, in the much-quoted station "in via ducente a vico Zele ad templum South Tawton, circiter 4 milliaria ab Okehampton, in comitatu Devoniae." As I know this particular lane quite well I am able to state that it is just such a locality as Schistostega best thrives in. Mr. W. P. Hiern, F.R.S., who has very kindly sent me Dickson's original description and much information relative to its early history, writes, "The collector was Sampson Newbery of Zele in the parish of South Tawton, Devon." As late as 1830, the date of the seventh edition of Withering's Arrangement of British Plants (**11**), only Devonshire localities are given, viz. the one just mentioned, one

or two places near Totnes, and near Meavy parsonage. A note, however, states that a new station had been recorded "by an unknown friend in April 1826, Gallow's Hill in Nottingham Forest." These localities correspond with those given by Braithwaite, which are presumably arranged in chronological order, and the "unknown friend" of Withering would appear to be Jowitt. Withering confused *Schistostega osmundacea* Mohr and *Pterygophyllum* (=*Hypnum*) *lucens* Brid., a very different plant, and attributed to this species the luminous appearance peculiar to Schistostega as well as Bowman's station, Rowter Rocks, Derbyshire. Since Newbery's day so many records have been made that it is now known to be a widely distributed moss, twenty-two county and vice-county divisions from Cornwall to Stirling possessing it in the British Isles alone (**23**). The lane at Zele is on the northern confines of Dartmoor, and Dartmoor may be considered a centre of distribution for Devonshire, for among its tors and rocks it is abundant and widespread. It would appear to thrive best in granitic areas, as it becomes increasingly rare in Devonshire beyond the influence of granite intrusions. It is not infrequent around Silverton (**12**), north of Exeter, a district invaded by the granite of Dartmoor; in East Devon it is quite a rare moss.

On Dartmoor it grows in narrow rocky crevices, principally among the tors, in disused mine adits, and in old rabbit burrows and fox holes. From very extensive observations of the habitats on Dartmoor I have elicited the fact that these invariably face north to east, while the moss itself in the majority of instances occupies a position that gives it a northerly aspect. This observation is the result of the examination of dozens of localities on Dartmoor in which compass bearings were taken. At my request Mr. F. R. Rowley, F.R.M.S., of Exeter, noted the bearings of all the localities he found for this moss on Dartmoor during a month's holiday there, and found them to face north to north-east. An area of Dartmoor in which this moss is particularly plentiful is the scarred and broken ground around the Vitifer tin mines. In the old tin gullies that reach up nearly to the top of Birch Tor rabbit burrows are so plentiful that "The Warren" is a local appellation, and it gave me a very good opportunity of testing the accuracy of the observation. In no instance did I find Schistostega in a burrow facing south or west. One of the few

places in East Devon where this moss occurs is in a large and disused rabbit-burrow, near Sidmouth, which also faces north-east. The most striking instance of the heliotropic adjustment of this plant with which I met was in the neighbourhood of Lydford on the western fringe of the moor, and as it is very illustrative of the habitat of this markedly heliophobic plant it will perhaps be of interest if it is described somewhat fully. On the north-western slope of Great Links Tor is an old stone hut

"THE SHEPHERD'S HUT."
Scale 1 :30.
Fig. 1.

called locally "The Shepherd's Hut," and of which a diagram is given (fig. 1 in text). It has been formed by hollowing out the ground underneath a huge block of granite which forms the roof; the walls are formed partly by the earth where it has been cut away and partly by blocks of granite built up to support the overhanging slab. An opening of about three feet square on the north-west side gives entrance to the hut or cave, which is more or less circular, with a diameter of about six feet and a present height

of not more than four. The hut circle, for such it practically is, while not in any way prehistoric is of very considerable antiquity, and probably was constructed as a temporary dwelling, or cache, by tin miners in the days of the tin-streaming industry, as old furrows are plentiful in the neighbourhood. As will be seen from the diagram, Schistostega occupies a position in the interior on the south side of the bank of earth, where it faces due north. Here it grew luxuriantly, and was fruiting abundantly at the time of my visit. Now it is obvious that the part of the hut wall to the left of the bed of Schistostega, being to westward, would get less light, while that to the right would have considerable illumination in the late afternoon owing to its facing north-west. A careful examination of the area covered by the moss indicated that its ecological optimum was at the position where it faced north, as on either side its growth thinned off, on the one hand into light of a low, and on the other into light of a relatively high intensity. These mediaeval caches are not infrequent on Dartmoor, more especially to the south of Princetown, and they are almost always associated with a luxuriant growth of *Schistostega osmundacea*.

From repeated photometric examinations by Wiesner's method **(13)** I have estimated the specific light-ration of Schistostega to be 1/50th of the total unobstructed light, but however carefully conducted they may be such estimates can only be an approximation to the actual light-ration of the plant. Wiesner's method depends on the darkening of silver bromide paper to a standard tint, and as the silver haloid used in the preparation of the sensitive paper is principally sensitive to the blue-violet rays it follows that a measurement of light made in the open with an abundance of the more refrangible rays cannot compare satisfactorily with a measurement made at a point where the light to which the photometric paper is exposed has the blue-violet rays filtered out to some extent by passing through a screen of foliage more or less dense.

Small as the light-ration of Schistostega may appear, it is comparatively generous when compared with that of such a plant as *Aspidistra elatior*, whose ration is only about 1/200th of the total diffused light outside **(14)**, and it should be remembered that the chloroplasts of sciophilous plants are more sensitive to weaker rays of light than are those of heliophytes **(15)**. The striking bluish

metallic lustre of many plants growing in deep shade is very apparent in *S. osmundacea*, more especially in plants which are vigorous in growth. Occasionally plants are met with that approach in colour normal, or even slightly yellow, green; but such plants are probably old or lacking in vigour, as strong, healthy plants exhibit the glaucescent lustre in a very marked manner. It is perhaps worth mention that one or two other species of mosses are quite frequently found associated with Schistostega, such as, for instance, *Plagiothecium depressum* Dixon, *Webera proligera* Bryhn, etc.; and as these species grow equally well in light of a far greater intensity, it points to the fact of their having a considerable range of adaptation. Nor, so far as I have been able to make out, does their association with Schistostega in its feebly illuminated habitat entail any modification of their structural details.

Schistostega is a sufficiently striking plant to make its identification quite easy when its habitat is once comprehended, and Dixon has aptly described it as resembling miniature fronds of *Lomaria spicant*. Individually it is 8–12 mm. in height and forms beds several inches square, usually on the sides of the burrows and crevices in which it dwells, more rarely on the floors. It has been frequently described as growing in *wet* sandstone caves. I have never yet found any plants of Schistostega in a locality that could with accuracy be described as wet; on the contrary it seems to avoid such spots. The Dartmoor localities, which from its abundance and luxuriance may always be regarded as representing the ecological optimum of this plant, are by no means wet; in fact the absence of anything like coherence in the soil upon which it is found growing makes it a very difficult plant to collect satisfactorily, as it so readily becomes disintegrated on detachment that the plants are lost amongst a handful of loose earth. It would be more correct to describe its habitat as a damp one. At the same time so good an authority as Mr. A. D. Michael, F.L.S., has given a description (**16**) of a cave in Cornwall he visited which was said to contain this moss. It is described as a cave with dripping sides on the sea-shore, inundated by high spring tides. The description of the greenish glow seen when standing at the mouth of the cave is quite indicative of Schistostega, but the statement that the same glow was apparent in the small pools on the floor of the cave scarcely suggests this moss.

I myself have never seen Schistostega in such a markedly maritime station. Mr. Michael adds that he collected some of the growth both from the sides and from the pools, but found only Diatomaceae. This, however, does not disprove the presence of the moss, as its minute fronds are extremely delicate and would easily be rendered unrecognisable in a heterogeneous mass of material.

The fruit appears to be somewhat rare, though when fertile the capsules are often produced in abundance. A great help in the distribution of the plant is afforded by the extremely deciduous nature of the capsule, brought about by the structure figured in Plate 23, fig. 3, and which appears to have escaped the notice of bryologists, as I have seen no reference to it in any literature I have consulted. The perichaetium in Schistostega is stalked, unlike the majority of mosses in which it is sessile; the proximal end of that portion of the seta bearing the capsule, and which is the true seta, is bulb-shaped and composed of large irregular cells. This bulb-like portion fits in the hollowed receptacle of the vaginula, the whole forming a ball-and-socket arrangement. When the capsule is mature the large spongy cells at the base of the seta contract, causing it to fit so loosely in the vaginula sheath that a very slight touch is sufficient to dislodge it. Quite early in the life of the sporogonium, even before the rupture of the venter, the ball-and-socket arrangement has already been formed (Plate 23, fig. 4), and the seta may easily be forced away from the vaginula by placing a cover-glass over a female plant and applying a little pressure. Only one archegonium is present in the female plant, and there are no paraphyses. A further aid in the distribution of the plant is the presence of abundant gemmae, which obviously are easily conveyed by the fur of rabbits from one burrow to another. It is very curious that these gemmae have hitherto escaped notice in this country. I myself never noticed them in any gatherings until the autumn of 1917, when I first found them abundant in some gatherings made on the moor near Lydford, and correspondents who have at my request specially examined their gatherings for their presence write saying that they have failed to find any.

My observations suggest the conclusion that these gemmae are principally produced when barren conditions of the plant prevail; although they may be present in fruiting communities.

they are so to a very much less extent. I have colonies of Schistostega growing in captivity from various localities on Dartmoor which rather confirm this view; they are kept quite separate and are all extremely healthy and vigorous. One colony is, and has been since it was first collected, quite barren, but produces an abundance of gemmae; another in the spring of 1917 was covered with capsules and at the present time is again covered with ripening capsules, but gemmae are very infrequent. Such a correlation is repeatedly met with among mosses, as for instance the deciduous leaves in barren states of *Campylopus pyriformis*, Brid., which condition is scarcely developed when the plant is fertile. These gemmae are multicellular, club-shaped bodies of about 100μ in length produced from the distal end of a filament of the protonema by a cell becoming enlarged and ultimately separating itself from the parent cell by the development of a separation cell (Plate 23, fig. 5). A new protonema may be produced by budding from one of the cells of the gemma (Plate 23, figs. 6, 7); or in rare instances the gemma may produce another gemma without the production of protonemal growth (Plate 23, fig. 8). These gemmae secrete a material of great adhesive power by which they become attached so firmly to foreign bodies that some force is necessary to dislodge them. Apparently the mucilage is excreted by the cells at the distal end of the gemma, as I have never seen one affixed by any other part of the bud. Yates has called attention to a similar phenomenon among the Hepaticae (**17**).

It is the protonema of Schistostega that gives it the great interest it possesses for the biologist, and which is probably unique in the vegetable world in its highly developed system of photosynthetic cells. Bowman quite early in the history of the plant gave a description of the convex light-cells and their function (**18**), and of late years much work has been done on them principally by Noll (**19**) and Vuillemin (**20**). The protonema is generally regarded as persistent, unlike the majority of mosses in which it disappears on the establishment of the plant, but I do not think that it can be regarded as essential to the life of the adult plant, for in those colonies I have growing in confinement it is reduced almost to extinction when the plants are full grown. One has to remember that a patch of Schistostega usually contains all stages of growth simultaneously, and my examination of such patches leads me to infer that it is the younger portions of the colony that produce

the protonema with its differentiated light-cells, for in one part a thick mat of protonema and young plants may be seen while a contiguous patch of adult plants bearing capsules may be practically without any protonema. The function of the protonema being the protection and nourishment of the bud in its early stages, it would obviously not be required when the plant was able to maintain itself; and as the adult plant of Schistostega produces an abundance of rhizoids which fix it independently to the soil, the necessity for the existence of the protonema ceases. As far as the adult plant is concerned the protonema is certainly, in a strict sense, not persistent, but it may always be in existence in some part of the colony. It is undoubtedly a very variable

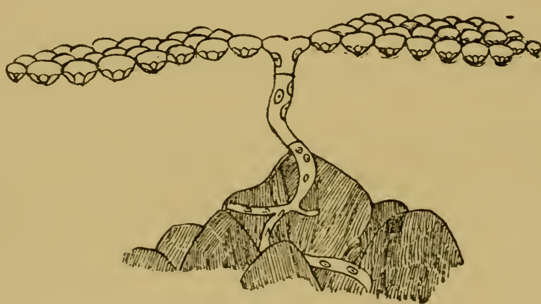

Fig. 2.

Photo-synthetic system of light cells.
(After Noll.)

production. In some instances I have had thick felted masses of bipinnate threads, as shown in Plate 23, fig. 9, with practically no light-cells; in other growths the light-cells predominated, and the simple bipinnate stage is probably the early stage of the photo-synthetic system, as I have had whole masses which exhibited the light-cells arranged in a beautiful bipinnate manner. Noll has given a figure of the protonema which shows it as a dendroid structure, the light-cells being arranged in two flat tables one on either side of an upright stem, which arises from a basal protonema (Fig. 2 in text). I have never seen anything so regular and symmetrical as this figure of Noll's indicates. Usually the photo-synthetic system, although elevated above the basal

protonema, is spread out in an irregular superficial series of cells of greater or less extent.

In examining the protonema of Schistostega one cannot fail to be struck by the nodular condition (Plate 23, fig. 10) the cells assume, even when they do not develop into the advanced stages shown by the flask-shaped and obconical light-cells. It would appear that any cell is capable of producing a distension that may ultimately become either a flask-cell or a light-cell. The flask-cells were first noticed by Correns (**21**), who described them as a form of gemma. Later Grout (**22**) called attention to them as existing in gatherings of Schistostega made in America. I have frequently met with them in my own gatherings, and at first, influenced by the views of Correns and Grout, I regarded them as a form of gemma. This, however, they are not; being merely the separation cell remaining after the liberation of the true gemma. Fig. 11, Plate 23, shows one of these flask-cells remaining attached to a portion of the protonema filament, but occasionally the entire filament seems to be given up to the production of the gemmae, as may be seen from a consideration of fig. 1, Plate 24, in which numerous separation cells are shown from which the gemmae have fallen; at *A* a gemma is forming by enlargement of the distal cell, and *B* shows the initial stage in the production of a flask-cell. It is interesting to note that the globose base of the flask-cells which bear the gemmae often produce the characteristic bowl-shaped chloroplast, as will be seen on reference to Plate 23, fig. 11, A, and again in Plate 24, fig. 1, C. There appears to be no stability in the form of any of the variously shaped cells to be found in the protonema. The narrow elongated cells may bulge at some point and a light-cell be produced, which may elongate and form a flask-cell, to give rise eventually to a gemma. One of the marked features of all the cells connected with the protonema is the large size and heliotropic arrangement of the chloroplasts, even when single and not bowl-shaped as in the light-cells. Braithwaite incorrectly describes the protonema as "composed of globose cells void of chlorophyll," and gives a figure that very poorly represents the actual structure. He also figures the leaf-cells as filled with minute grains of chlorophyll, whereas the chloroplasts are quite noticeably large and comparatively few in number, being oval and round and about 10μ in diameter. The cell itself is about 1/50 mm. in thickness, and the chloroplasts are

arranged principally on each surface of the cell wall (Plate 24, fig. 2). As the distichous leaves of the adult plant are set vertically on the stem, and as the stem grows usually at right angles to the incident light, the edge of the chloroplast is consequently presented to the action of light, though it would seem that a certain amount of translocation takes place, as many of the chloroplasts may be seen ranged along the side walls of the cells, in which position the whole surface of the chloroplast would be exposed to the action of light.

The light-cells themselves are obconical in shape and of about $30\mu \times 20\mu$ when at their maximum growth. They are produced from the end of a filament by a process of budding, and as previously mentioned they often assume a more or less regularly pinnate growth, and form a superficial aggregate of considerable size. They may on the contrary be sparingly developed and scattered singly or in small groups among the filaments. The distal portion of an ordinary linear cell becomes swollen and the chloroplasts become much enlarged, the next cell in series, produced by budding, is shorter and more globular; eventually the cells become quite globular and assume the ideal obconical form. Lateral budding takes place later until eventually the superficial aggregate is formed, Plate 24, fig. 3. The chloroplast of the ideal light-cell is bowl-shaped and fills the conical bottom of the cell to about one-third of its height as shown in fig. 4, Plate 24, where the obconical cells are shown in vertical section. Bowl-shaped chloroplasts are of frequent occurrence in the genus Anthoceros (Liverworts), they also occur in *Selaginella martensii*, but they probably are nowhere developed to such a state of efficiency as in the photo-synthetic system of Schistostega. In its most perfect form, which may be described as the "rosette" form, it consists of six wedge-shaped chloroplasts arranged in a circle around a seventh, which is central and lies at the bottom of the obconical cell. This ideal "rosette" chloroplast is seen in cell 5, fig. 3, Plate 24. It will be seen that a highly efficient photo-synthetic cell is produced by the obconical shape with the bowl-shaped chloroplast filling the conical base, their separate pieces so arranged as to present a uniform sheet of chlorophyll to the light condensed by the convex portion of the cell. On the budding of a new light-cell from a parent cell one or more chloroplasts pass into the new bud before it is separated from the parent (Plate 24, fig. 5), and

this chloroplast appears to enlarge by subsequent growth until it assumes a plate-like form, when it divides to form the "rosette" shape (Plate 24, fig. 6). In Plate 24, fig. 3, cell number 3 will be seen to contain a single "rosette" bowl-shaped chloroplast and several unassociated and irregularly shaped chloroplasts, one of which will pass into the new light-cell seen to be in process of forming at *A*. The light-cell with the "rosette" chloroplast is undoubtedly the ideal cell of the system, but the "rosette" shape is not always produced, it is frequently replaced by irregularly shaped chloroplasts which are also bowl-shaped. Cell 13 in fig. 3, Plate 24, shows a frequent type of irregular chloro-

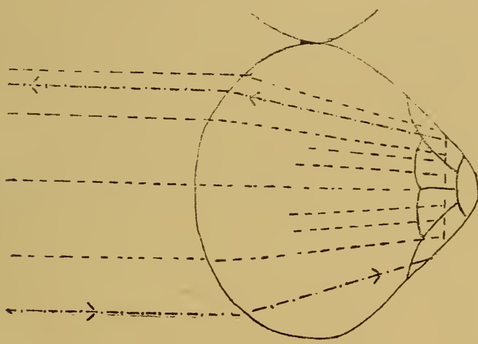

Fig. 3.

Diagram of light rays in ob-conical cell.

(After Noll.)

plast formed of four roughly triangular portions with their apices forming the bottom of the bowl. In some cases numerous large circular chloroplasts aggregate in an irregular manner at the bottom of the cell, but whether these combine and eventually form a "rosette" I have not been able to determine. It is, of course, these cells that produce the peculiar luminous appearance for which Schistostega is known, and Noll gives the following explanation (**19**)—" The rays of light which fall upon the cell are refracted and concentrated upon the chlorophyll grains. Owing to the shape of the cell the rays are totally internally reflected from the basal walls of the cells and are again emitted, which gives the

luminous appearance" (fig. 3 in text). Haberlandt states that "the chlorophyll apparatus in each funnel-shaped cell is so brilliantly illuminated that it acts against a dark background as a self-luminous body, any rays that are not absorbed by the chloroplasts being reflected and retraversing the whole optical system contrary to their path of entry" (**24**). When examining the "rosette" chloroplast with a high power I have noticed its surface to possess a decided burnished appearance. The researches of Guilliermond (**25**) would suggest that this is due to the pigment of the chloroplasts having assumed a crystalline state, and it will be seen that a highly crystalline state of the concave surface of the chloroplast would practically convert it into a parabolic reflector and explain in a large measure the green effulgence noticeable when looking at a bed of this moss. One remarkable feature of the light-cell producing portion of the protonema is the great variety of shape the chloroplasts assume in the effort of dovetailing together to form an unbroken surface of chlorophyll for the light to act upon. Cells number 1 and number 2 in fig. 3, Plate 24, well represent this dovetailing arrangement, which appears not to exist to the same extent in those parts of the protonema not directly connected with the production of light-cells.

My thanks are due to several who have generously given me help in the preparation of this paper. Mr. W. P. Hiern, M.A., F.R.S., very kindly transcribed and sent me much information relative to the discovery of the moss in Devonshire and its early history. Mr. H. N. Dixon, M.A., F.L.S., was good enough to look up and send me references to the literature dealing more especially with the morphology of the plant; while my friend, Mr. F. R. Rowley, F.R.M.S., of Exeter, generously devoted part of his holiday on Dartmoor to investigating the orientation of such beds of Schistostega as he came across. I have again to thank the Quekett Microscopical Club for extending to me the hospitality of its Journal.

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Description of Plates.

Plate 23.

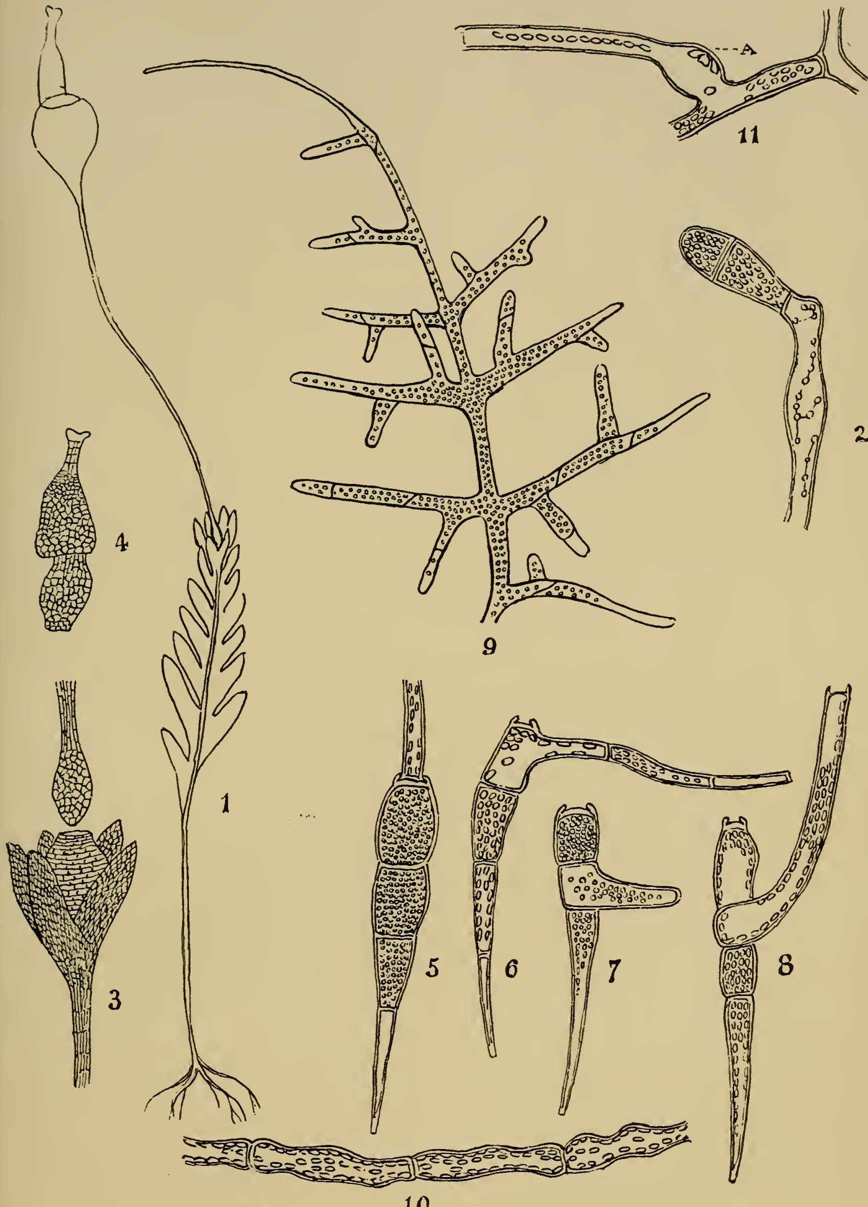
Fig. 1. *Schistostega osmundacea* Mohr. Fertile plant. × 16.
,, 2. Distal end of protonema producing gemma. × 300.
,, 3. Perichaetium showing ball and socket arrangement. ×35.
,, 4. Immature seta and calyptra. × 35.
,, 5. Gemma with separation cell. × 300.
,, 6. Gemma producing protonema. × 300.
,, 7. Gemma producing protonema. × 300.
,, 8. Gemma producing new gemma. × 300.
,, 9. Bipinnate arrangement of protonema. × 200.
,, 10. Nodular condition of protonema. × 300.
,, 11. Flask cell, with "rosette" chloroplast at A. × 300.

Plate 24.

Fig. 1. Protonema with flask-cells: A. budding gemma; B. early stage of flask cell; C. "rosette" chloroplast in base of flask-cell. × 300.
,, 2. Cells of leaf with chloroplasts. × 510.
,, 3. Photo-synthetic system with chloroplasts. A. budding light-cell. × 510.
,, 4. Bowl-shaped chloroplasts in light-cells, ver. sec. × 510.
,, 5. Budding light-cell with migrating chloroplast at A. × 510.
,, 6. Four light-cells showing various stages in the division of the chloroplast from a simple plate-like form commencing division to the bowl-shaped chloroplast of four pieces. × 510.
,, 7. Bud of new plant arising from protonema. × 300.

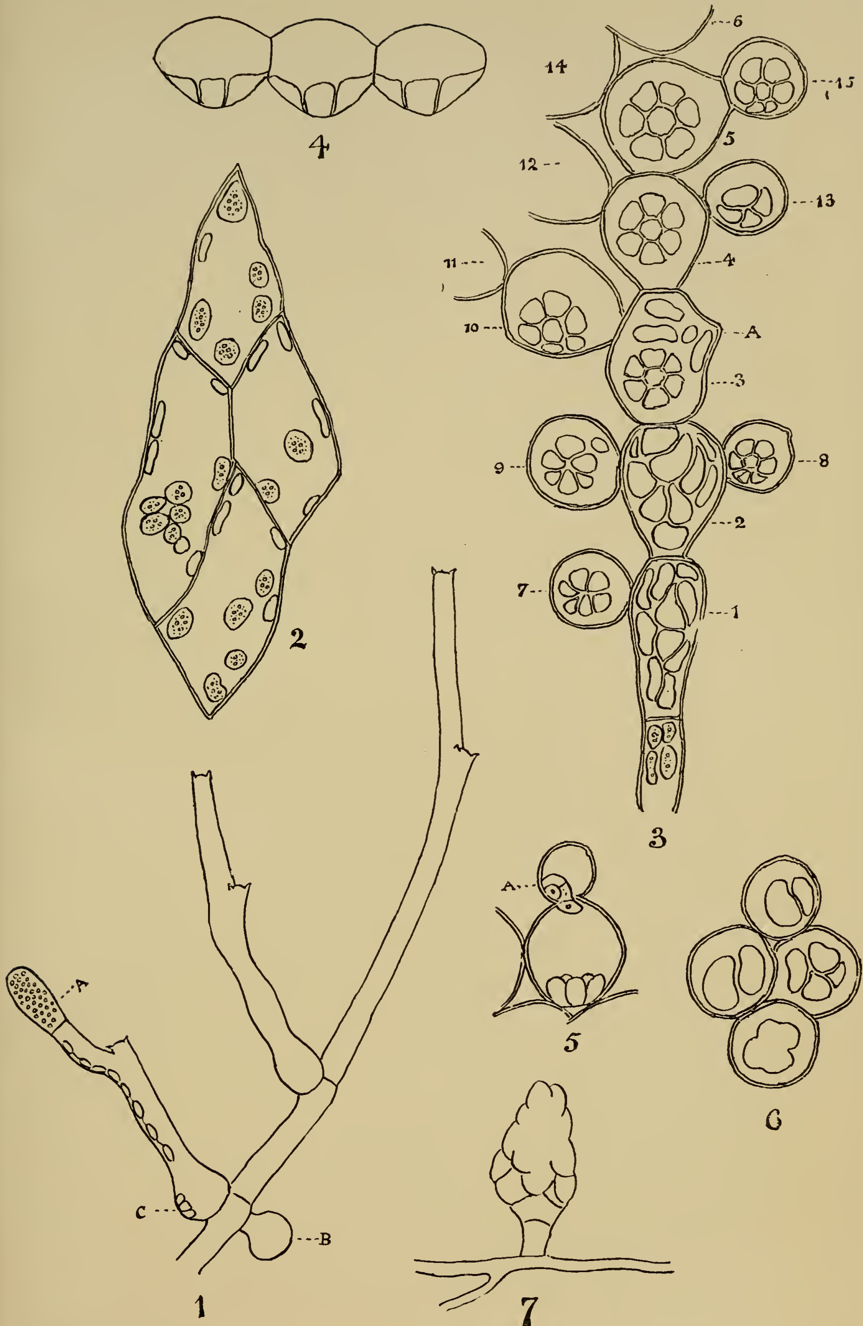
Figures in Text.

Fig. 1. Plan of "The Shepherd's Hut," Dartmoor.
,, 2. Photo-synthetic system of light-cells (after Noll).
,, 3. Diagram of light-rays in obconical light-cell (after Noll).



G. T. Harris, delin. ad nat.

Schistostega osmundacea Mohr.



G. T. Harris, delin. ad nat.

Schistostega osmundacea Mohr.

LEBERTIA SEFVEI WALTER.

By W. Williamson, F.L.S., F.R.S.E., and Charles D. Soar, F.L.S., F.R.M.S.

(*Read March 12th*, 1918.)

Plate 25.

Among the species of Lebertia, two, *L. giardinai* Maglio * and and *L. sefvei* Walter, † may be readily distinguished from the other members of the genus. This is due to the fact that they have the genital area enclosed by the fourth pair of epimera. The first of these was found in Italy and has the genital area in the male completely surrounded, while in the female the rounded inner posterior corners of the fourth pair of epimera come very close together behind the genital area, but do not quite meet. The second was found in Swedish Lapland, and differs from the former in that the fourth pair of epimera are separated by a narrow strip extending from the genital area to the rounded posterior margin. It may also be noted that in *L. giardinai* the spines of the palpi are pectinated, and that the inner extremities of the second pair of epimera end in a point, while in *L. sefvei* the spines of the palpi are not pectinated and the inner ends of the second pair of epimera are broad.

The discovery of the Arctic form in Dartmoor brings the number of the Britannic species up to twelve.

L. sefvei belongs to sub-genus Hexalebertia and in length is a

* Maglio, *Rend. Ist. Lombardo*, Ser. II. xli. 3 ; *Atti. Soc. Ital. Sci. Nat. Pavia*, xlviii. 274–277, figs. 12–13. Monti, *Atti. Soc. Ital. Sci. Nat. Pavia*, xlix. 59–61, figs. 51–54.

† *Naturwissenschaftliche Untersuchungen des Sarekgebirges in Schwedisch-Lappland*, Bd. IV. 598–60, Pl. 9, figs. 11–13. (C. E. Fritzes Bokförlags-Aktiebolag—Stockholm.)

little over 0·7 mm. and about 0·4 mm. in breadth. In outline it is elliptical, broadly rounded at both ends. Between the antenniform bristles, it is slightly emarginate. The legs are yellow, the body colour darker with brownish patches on the dorsum. The skin is covered with short ridges of unequal length, those on the anterior half of dorsum, particularly between the eyes, being very short. As the ridges get nearer to the posterior, they increase gradually in length. Along the dorsum the direction is longitudinal, but as they pass round to the ventral area posterior to the epimera, the direction of these ridges becomes transverse. They are slightly sinuate and free from one another, exhibiting between them an indistinct porosity of the skin. The gland pores are encircled by a broad chitinous ring, but they do not stand out prominently from the surrounding area.

The capitulum is a little over 0·2 mm. in length, and lies in a long narrow bay formed by the first pair of epimera. The anterior processes are almost parallel, and both they and the posterior pair end in a sharp point. Seen from the side the ventral wall of the capitulum is bent somewhat in advance of the posterior processes. The ventral surface of the pharynx near to the thickened posterior is also seen to be bent.

The palpi are about 0·3 mm. in length. The second segment is stout and has its extensor surface well arched, with three moderately long spines midway, and two longer ones distal. The flexor surface is weakly concave with the long straight bristle not quite distal. The third segment has the six long bristles disposed similarly to *L. stigmatifera* Sig Thor. (*Zool. Anz.*, xxxii. 151, fig. 87*b*). The flexor surface of the fourth segment is almost straight, while the extensor surface is slightly curved, giving the segment the appearance of being tapered a little. At the distal end of the extensor surface there are four fine hairs. The minute hairs on the flexor surface are rather nearer to each other than to the ends of the segment.

The epimera are the prominent feature of the species and almost entirely cover the ventral surface. The posterior ends of the first pair end in a sharp point, and lie rather more towards the genital area than the capitulum. The posterior ends of the second pair are broad. The inner suture between the second and third pairs is drawn in towards the first pair. The third pair are triangular, the suture between them and the fourth

pair extending inwards for about three-fourths of the breadth. The outer margins have two or three long hairs. The fourth pair cover more than half the ventral surface and extend round the sides well beyond the third pair. The genital area is enclosed by them except for a narrow strip on the posterior median line. The fourth pair have the posterior margin well rounded towards the sides.

The first pair of legs are about 0·5 mm. in length; the second pair 0·6 mm.; the third pair 0·7 mm., and the fourth pair a little over 1 mm. The second, third and fourth segments of the first pair of legs have each one broad pectinated spine at the distal end while in addition the second and third segments carry a few short curved spines. The fourth and fifth have a few rudimentary hairs. Bristles are apparently confined to the third and fourth segments, which have one each distal. The first and second segments of the second pair of legs have each one long thin spine distal. The third and fourth segments have the distal ends fringed with broad pectinated spines, the largest being on the flexor surface. The fifth and sixth segments resemble those of the first pair of legs. The first four segments of the third pair of legs resemble those of the second pair, but with more numerous spines. The first segment of the fourth pair of legs has six or seven spines for the most part clustered at the distal end of flexor surface, and where it articulates with the second segment there are a few fine hairs. Distal spines of second and third segments short and pectinated. The spines on all the segments of the fourth pair of legs are relatively more slender and straighter than on the other legs. The fifth segment has a few fine spines and several fine hairs. Swimming hairs are either wanting or of a very rudimentary character.

As indicated above, the genital area is surrounded by the fourth pair of epimera, except for a narrow strip. In outline it is pyriform, with the usual anterior and posterior ridges for muscle attachment, which, however, do not appear to be linked up to the epimera. The posterior pair of acetabula are slightly smaller than the other two pairs. Along the inner edge of each valve there are about twenty hairs.

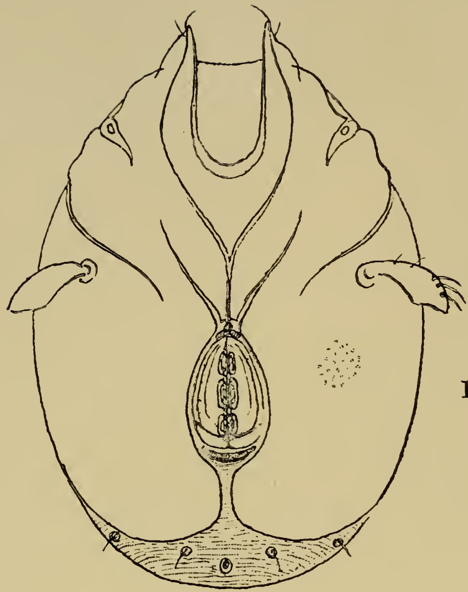
The anus is surrounded by a strong ring and has on each side a gland pore.

A single specimen of which the sex cannot be determined was

taken by Mr. D. J. Scourfield at Fernworthy Bog, Dartmoor, in August 1917.

Description of Plate 25.

1. *L. sefvei* Walter, Ventral surface.
2. *L. sefvei* Walter, Inner side of left palp.
3. *L. sefvei* Walter, Fourth leg.



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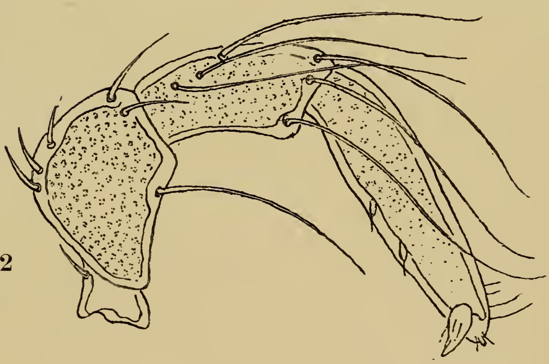

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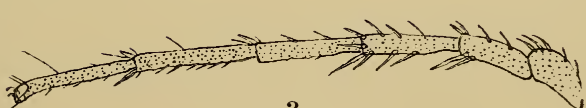


3

C. D. Soar, delin. ad nat.

LEBERTIA SEFVEI Walter.

NOTES.

ON THE MEASUREMENT OF MAGNIFYING POWER.

By Edward M. Nelson, F.R.M.S.

(*Read in title, January 8th,* 1918.)

The first duty of every one who has purchased a microscope is to determine the combined magnifying power of its various object-glasses and eye-pieces. The first three extras to be purchased should be a stage micrometer, a micrometer to drop into an eye-piece, and some sort of camera for drawing. The cost of these being about 5*s*. each, the outlay required is small, but it should be known that these three things are " essentials " if real microscope work in any branch is to be undertaken.

On a previous occasion (June 24th, 1913) I brought to your notice a method of measuring the magnifying power of a microscope, June 1913 (Ser. 2, Vol. XII., No. 73, p. 239), and now I propose to lay before you a better plan.

As the measurement of the various objects upon which one is at work is a most important microscopical duty, it is necessary to know the value of the divisions in the stage micrometer in terms of the eye-piece micrometer. These values for all the objectives in the microscopist's battery should be entered on a card and kept with the microscope in its box. This is the simplest of all microscope measurements, for it consists merely in finding out how many divisions of the eye-piece micrometer are required to span 0·1 mm. on the stage micrometer. When these values are known the size of any object can be at once calculated. I have published a small table * to save the microscopist the trouble of this calculation. In that table these values, viz. those of the

* *Micrometric Table* by Edward M. Nelson. H. F. Angus & Co., 83, Wigmore St., London, W. (1914). 3*d*.

stage micrometer in terms of the eye-piece micrometer, are called *M*, so we will continue to represent them by that letter.

The determination of the combined powers of a battery of object-glasses with various eye-pieces is a tedious business. There are various ways in which it may be done; one is by projection in a photomicrographic camera; another, and more usual plan, is by means of a simple form of camera, such as a Wollaston's camera or Beale's neutral tint, to cast down the image upon a divided ruler; these methods are so well known that further description is unnecessary. The new plan is as follows: After having found the value of *M* for each objective in the battery, one object-glass is selected (preferably one of medium power, say 1/2-inch), and by one or other of the above methods the combined magnifying power of this object-glass with all the eye-pieces is carefully measured. These measurements are then divided by the *M* value for that object-glass. This gives a constant for each eye-piece. The combined power of any other object-glass with any eye-piece whose constant is known is found by multiplying the constant of the eye-piece by its *M* value.

I have just arranged a battery of twelve object-glasses and four eye-pieces with a microscope for work on pond life. The *M* values of the object-glasses were carefully measured, the combined power of one object-glass, the 1/2-inch, was also measured, these data gave the constants of the eye-pieces, then the combined powers of the remaining eleven object-glasses with the four eye-pieces were read off a slide rule, at sight, without any trouble at all. Example:

Eye-pieces	No. 1.	No. 2.	No. 3.	No. 4.	*M*.
Constants	8·77	12·68	14·90	20·09	
Objective, 1/2-inch . .	103	149	175	236	11·75
Objective, 1/6-inch . .	290	420	500	670	33·33

Here 103 divided by 11·75 is equal to 8·77, the constant of No. 1 eye-piece; this constant 8·77 multiplied by 33·33 gives 290, the power of the 1/6th with No. 1 eye-piece, and so on.

Perhaps some would prefer the reciprocal method; for necessarily the result is the same whether a number is multiplied by another or divided by its reciprocal. The following example will explain.

Divide 100 by M, which will give the value of one division of the eye-piece micrometer in micra. This is useful where the measurement of any object is some simple number of eye-piece divisions.

With the same 1/2-inch we have $100/11{\cdot}75 = 8{\cdot}51$ micra. Therefore if any object spanned two or three divisions its size is known at sight. (The card of magnifying powers, which I put in the box of the new binocular, has both M and 100 times its reciprocal given, the tube length being 211 mm.) To find the constant of the eye-piece: The combined magnifying power of this objective and each eye-piece must be multiplied by this quantity 8·55; thus for No. 3 eye-piece we have $175 \times 8{\cdot}51 = 1{,}489$, the constant. If this constant be divided by the value of an eye-piece division in micra for any other objective it will give the combined magnifying power; thus for the 1/6th object-glass where $100/M = 3{\cdot}0$ we have 1,489 divided by $3{\cdot}0 = 500$ as before.

The systems are the same, except that division is substituted for multiplication and *vice versa*. As division is arithmetically more laborious than multiplication, this system is hardly so convenient as the other, but when logarithms or a slide rule is used there is no difference between them.

CARL DIETRICH AHRENS.

(*Died March* 14*th*, 1918, *aged* 81.)

WITH the death of Mr. C. D. Ahrens * a notable worker in the optical and microscopical worlds has passed away. By trade he was a prism and spar slitter. He made Nicol prisms and analysers, quartz and calcite prisms of all kinds, as well as the glass prisms for Wenham binoculars. In 1867 he designed a binocular upon quite a novel plan. The rays issuing from the back of the objective were separated to an angle of 15° by a double-image calcite prism; these rays were then crossed over by two flint prisms, to correct the chromatic dispersion. The rays used were the extraordinary, the ordinary being diverted out of the path. The tubes were equally inclined to each other. He says that "the plan may not be so good as the Wenham for low powers, but for high

* Ahrens was born in Hanover in 1837, and as it had not then been ceded to Germany, he was by birth a British subject.

powers I cannot conceive anything finer." It also formed a binocular eye-piece and was about the first to be made. In 1881 he introduced another new binocular, in form like Stephenson's. It had parallel tubes, but they were bent as in the Stephenson. The ingenious part of the arrangement was that the beam from the back of the objective was divided by two Wollaston camera-lucida prisms placed back to back; these deflected the rays right and left, then another prism with two reflections bent them up the tubes. Probably a carefully made binocular on this plan would be a very successful instrument. In 1884 he designed a bent-tube erecting monocular microscope; obviously a most useful instrument, it is surprising that some energetic manufacturer has not taken up this idea.

In the same year he designed a new polarising prism which was further improved by Mr. H. G. Madan in 1885. In 1886 he brought out yet another improved form of polarising prism, the object of which was to lessen the ratio of its length to its breadth. That of the Nicol is about 3 : 1, while the Ahrens was $1\frac{1}{2}$: 1. In 1887 he made an erecting microscope the design of which has had far-reaching consequences. The erection was obtained by Porro prisms. A description of this instrument, with figure, appeared in the *R.M.S. Journal* for 1888, p. 1020, fig. 161. He said that "the erection of the image is obtained by two right-angled prisms crossed in the way used in some of the binocular field glasses." This naturally came to the notice of Mr. J. W. Stephenson, the treasurer of the R.M.S., who was especially interested in binoculars and prisms of all sorts. He applied to Ahrens and asked if he could supply him with one of these binocular field glasses. Ahrens replied that they were difficult to make and would cost some £25. Mr. Stephenson thought this too high a price, and wrote to Prof. Abbe, with whom he was in frequent correspondence, to ask if the Zeiss firm would send him a quotation for a pair of these field glasses. This letter of Stephenson set Prof. Abbe on the subject, and so was the cause of the introduction of these wonderfully useful glasses. (It is not at all unlikely that Porro got the first idea of erection by two right-angled prisms from Zahn's *Oculus Artificialis*, a book published in 1702, where there is a figure of a telescope doubled up in a similar manner by right-angled reflecting mirrors). It was Ahrens, however, who first brought the long-forgotten Porroprism to remembrance. The difficulty in the con-

struction of a prism binocular field glass was at that time little understood, and has not been as yet pointed out in any treatise on optics. The curves of the objectives must be altered so as to balance the undercorrection caused by the prism. Prof. Abbe saw that this undercorrection was fully compensated for, and therefore these glasses were from the first a great success. Now with regard to the Greenough binocular. The twin microscope binocular was invented by Père Cherubin d'Orleans in 1677, but as the microscopes were of the ordinary inverting form the image was pseudoscopic. To remedy this, erecting eye-pieces of Rheita's pattern were added; these certainly changed the pseudoscopic vision to orthoscopic, but owing to the great increase in the length of the body the inclination of the tubes to one another was so much reduced that very little stereoscopism was left in the image. A twin-microscope binocular must have short bodies, and it was this microscope of Ahrens which made the twin-microscope binocular a practical instrument.

Edward M. Nelson.

Another link with the past has just been broken by the death of Carl Dietrich Ahrens at the ripe age of eighty-one. A skilled handicraftsman with a distrust of all machinery for the doing of his beloved work, he was a typical representative of the pioneer artists who so often labour so diligently to lay the foundations of a new industry, only to find that the more successful their work, the more unnecessary their own activities ultimately become, as labour-saving machinery is introduced to meet the demands their own work has created.

Ahrens' best work was undoubtedly done in the making of the large Nicol prisms which have been so closely identified with his name for the last half-century. At such work he was an artist. Possessing but a very limited amount of theoretical knowledge, his instinctive knowlege of the optical effects of Iceland spar, quartz and other double-refracting media, when cut and combined in various ways, was wonderful; and no one had quite the success in the important operation of cementing such prisms that he had. For many years, in fact until just before his death, the cement employed by him was kept as a great secret. It is now known, however, that he used nothing

more than gum copal dissolved in turpentine. It is open to question, however, whether the good results that he obtained were not, in the main, due rather to the extreme care taken in the process than to the cement itself. A fine pair of prisms representing Ahrens' best work, with an aperture of about $3\frac{1}{2}$ inches, have fortunately been secured for the Science Museum, South Kensington, together with a fine collection of projection preparations for the prisms. Ahrens did a great deal of work besides that already referred to. As time advanced, however, he had it borne upon him that the demand for his work was decreasing. The various optical elements upon which he had specialised became ultimately in such great demand that the introduction of machinery for their manufacture was called for. Then Ahrens discovered, to his sorrow, that his erstwhile customers preferred to go abroad for these optical appliances, where they could obtain them cheaper and probably better made.

Personally Ahrens was a man of strong and independent character—strictly honest in all his dealings, and, poor though he was, autocratically selecting his own customers. His death leaves a vacancy which it will be difficult to fill.

FREDERIC J. CHESHIRE.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 527th Ordinary Meeting of the Club, held on October 23rd, 1917, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on June 26th were read and confirmed.

Mr. Alfred W. Alabaster was balloted for and duly elected a member of the Club. Nomination forms for six others were read for the first time.

The President informed those present that the committee had decided, until further notice, to hold the Ordinary Meetings on the *second* Tuesday in each month instead of on the fourth, the "Gossip" Meetings being held on the fourth Tuesday.

Dr. G. H. Rodman, F.R.P.S., then gave a lantern demonstration of photomicrographs. In a short introductory address he said he considered it a great compliment to be asked to give his demonstration and to address the opening meeting of the fifty-third session of the Quekett Microscopical Club. He was more accustomed to address photographic societies than practical microscopists of such repute as the Quekett Club contained. He wished to bring forward a plea for recording by photography the magnified images of objects as observed on the microscope stage. The photographic plate reveals a great deal, and if given the opportunity will render a satisfactory picture, as well as record truthfully what is made evident by the microscope. The photographic camera has a keener eye than a human being. He had sometimes found whilst developing a plate that a spot appeared which gave him considerable anxiety, but when the process was completed it turned out to be a true record of some detail which had been and might have been easily overlooked by anyone using the microscope only in the ordinary way. As an illustration of the greater sensitiveness of the photographic plate as

compared with the human retina, the lecturer said a photograph might be taken of a quickly moving vehicle, such as a dog-cart, when on the plate the spokes of the wheels would all be distinctly evident and well defined, but to an observer's eye they would present nothing but a blurred and indistinct view. The use of the camera lucida for securing representations of the magnified image and some of the difficulties of its employment were then referred to. It was remarked that in the hands of such an expert as Tuffen West the results were excellent, but the personal factor comes in strongly in the use of the instrument, and not infrequently the resultant drawing is a representation of what the observer thinks he sees, or has seen represented elsewhere, rather than of what is actually present. The chief objection usually found in the photograph is the lack of depth of focus, but this can be supplied to a great extent by the use of a Davis's shutter behind the objective, cutting down the aperture of the objective; in fact, dealing with the micro-objective in the way that a photographer would stop down his lens, say, to f/32. The rule of the use of a small aperture for securing crisp definition and obtaining sharpness in different planes is well recognised by the camera expert, and Dr. Rodman attributed a great deal of his success in photomicrography to his observance of that rule. Various methods of illumination for photographic purposes were discussed, the Nernst lamp, when obtainable, being recommended. As an example of the results obtained by the photographic and the camera-lucida methods, the lantern view of a beautifully finished pen-and-ink drawing of Paramecium in conjugation, at a magnification of × 300, was thrown on the screen. In this the details of structure came out very finely, the cilia round the bodies being perfectly distinct. The photographic record in this case was unsatisfactory, details being absent. But it was confessed that the camera-lucida drawing was not exactly the true record as obtained with that instrument: it had been improved afterwards and details added. The photomicrograph obtained from the same micro-slide from which the camera-lucida drawing had been made was then projected for comparison, and showed by an absence of many of the characters of the drawing that the latter had been produced at the cost of a good deal of artistic licence, and was quite untruthful in many points. In another example, however, the photomicro-

graph of Sertularia showed on the screen all details, and was, of course, an exactly truthful representation, while the drawing made with the camera lucida was very much less satisfactory in many respects.

A series of lantern views of about 100 photomicrographs was then thrown on the screen; they were drawn from nearly all classes of microscopic work—insects, pond life, botanical subjects, marine objects, geology, histology, diatoms and foraminifera being all copiously represented. The particular point which Dr. Rodman desired to emphasise—viz. the possibility of obtaining a very considerable depth of focus, giving a marked stereoscopic effect—was distinctly evident in many examples in all classes. Some diatom slides exhibited this feature excellently, and formed most beautiful objects, with depth, and yet great sharpness of detail. A slide of Heliopelta, and several strewn slides of perfect specimens, may be particularly noticed. Foraminifera, of course, illustrated this special feature extremely well, as did many botanical objects, some slides of pollen being noticeable amongst them. Especially effective were photographs of various plant hairs, the stinging-hairs of the nettle, and hairs on leaves of *Rosa rugosa*, *Onosma alba*, Pelargonium and Sage, among others, standing out with stereoscopic distinctness.

At the conclusion of the exhibition the President said Dr. Rodman had put his arguments in favour of photography before the meeting very effectively. His own view was that either method was a means of collecting facts, and it was evident that it would have taken anyone a very long time to depict the objects by means of the camera lucida. At the same time, the camera lucida is a valuable instrument. In fossil botany, for instance, the student very often has to work with very imperfect material, but by using a camera lucida he gets the proportions correct, and constructs his drawing by combining facts which have been brought before him by various specimens. He suggested a vote of thanks to Dr. Rodman for his interesting communication, which was heartily given by acclamation.

A paper by Mr. C. F. Rousselet, F.R.M.S., "Further Notes on Collecting and Mounting Rotifera," and one by Mr. W. M. Bale, "On Measuring the Magnifying Power of the Microscope, a Simple Method," were, owing to shortness of time, read in title only.

At the 528th Ordinary Meeting of the Club, held on November 13th, 1917, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on October 23rd were read and confirmed.

Messrs. Arthur R. Trist, Geo. H. Rodman, Gustasp Andaseer, R. Guthrie Woodward, Stuart Lawson and Wilfrid J. Birch were balloted for and duly elected members of the Club. Proposal forms for two candidates were read for the first time.

The President announced that Mr. Ingpen, Honorary Secretary from 1873 to 1883, had very kindly presented his microscope to the Club. It was exhibited on the table, and included a valuable set of accessories; in addition to the instrument itself—a monocular, with very complete mechanical substage—there were three condensers, a full set of five eye-pieces, an extra draw-tube, a camera lucida, a polariscope, and an Abbe apertometer, with some other apparatus. In a letter to the President accompanying the gift Mr. Ingpen explained that the instrument was a testimonial given to him by the Quekett Club on his relinquishing the secretaryship; it had been constantly used, and was greatly valued by him. Now, however, owing to advancing age and the failure of his eyesight, he was unable to continue his work, and thought that he could not do better than return it to the present representatives of the donors for their use, with his best wishes for the continued prosperity of the Club. It was unanimously resolved that the thanks of the members should be expressed to Mr. Ingpen for his gift, coupled with their sympathy with him in his sad affliction.

Dr. Rendle announced the death at an advanced age of Dr. Robert Braithwaite, F.L.S., F.R.M.S. He joined the Club in 1865, was President in 1872–3, and had been an honorary member since 1893. He was the author of a valuable series of papers on the Sphagnaceae, and his *British Moss Flora* was well known. He was President of the Royal Microscopical Society in 1891–2.

Dr. J. Rudd Leeson, F.L.S., F.R.M.S., then gave an address on "The Life-History of the Gnat (Culex)," which was illustrated by micro-preparations exhibited under microscopes on the table. The Culicidae were characterised by their hair-whorled antennae, the proboscis, and scales on the wings. All so-called mosquitoes belonged to this order. There were about a dozen species known in Great Britain. The larvae were

aquatic, and in order to understand their life-history the surface tension of water should be studied, as it was essential to the life of the gnat, which in all its phases was an air breather. The eggs were laid in the form of a floating raft, about a quarter of an inch in length, containing some 250; they were cigar-shaped, pointed above and with a lid below, from which the larvae emerged. The larva was heavier than water, yet required to breathe the air; for this purpose a posterior breathing-tube, known as the respiratory siphon, arose from the eighth abdominal segment, and at the end was armed with five cusps, which, when expanded, supported the creature tail upwards, by virtue of the surface tension; its head meanwhile sinking in the water, from which its food was obtained. When alarmed it withdrew the cusps and was able to progress by using the swimmerets at the end of the body. After three or four months it pupated and the pupa did not feed, but it was requisite that the head should be towards the surface for the emergence of the perfect insect. To accomplish this, two trumpet-shaped breathing-tubes were developed from the back of the head, and these, owing to the surface tension, were able to support the creature in the new position. Finally, the pupa-case split along the back, and the gnat, withdrawing from it, began its new life in the air. In reply to questions, Dr. Leeson said the blood-sucking function was not well understood. Swarms of gnats inhabited the Arctic regions where no animals existed from which a supply could be drawn, so that the propensity could hardly be considered essential to its existence. As the males did not suck blood, it might, perhaps, be an accompaniment of the reproductive function. The danger of contracting malaria from the bite depended on the presence of infected people in the area from whom the parasite might be transferred. Mr. N. E. Brown referred to the dissemination of ague by *Culex pipiens*, and Mr. Grundy remarked that ague in India was almost certain to follow the bites of various gnats. After some observations by the chairman, a hearty vote of thanks was accorded to Dr. Leeson for his communication.

Mr. Jas. Grundy, F.R.M.S., explained the polarising apparatus given with the microscope by Mr. Ingpen. The theory of polarised light, and the differences between plane, elliptical and circular polarisation, were referred to. It was shown how rays of light passing through the polariser were divided up into ordinary and

extraordinary rays, and from the relation between the refractive index of calcite and that of the extraordinary ray this ray went nearly straight through the polariser, and emerged as a plane polarised beam of light, whose vibrations were parallel with the short axis of the Nicol's prism, this being the principal way of obtaining plane polarised light. Also the ordinary ray for a similar reason could not pass through the polariser beyond the dividing plane cemented with Canada balsam, but was refracted at the surface of the balsam and lost. The analyser, which is a prism similar to the polariser, treated rays of light in the same way, and there the emergent rays vibrate again parallel to the short axis of the Nicol; only doubly refracting material is effective for observation with polarised light, because unless it is doubly refractive interference cannot be obtained, and therefore no colour due to polarisation occurs. The President said it was fortunate that Mr. Ingpen's gift had formed a subject for an address on polarised light, and he suggested a hearty vote of thanks to Mr. Grundy for his explanation; this was given unanimously.

At the 529th Ordinary Meeting of the Club, held on December 11th, 1917, Vice-President D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on November 13th were read and confirmed.

Messrs. Edward Hight and Evan V. Pike were balloted for and duly elected members of the Club. Nomination forms for two candidates were read for the first time.

The chairman announced that Mr. C. F. Rousselet had presented to the club several portraits, and also a further collection of photographs of drawings of Rotifera to be added to those he had already given. He said that Mr. Rousselet's health was slightly improved, and expressed the hope that it might in time be sufficiently restored to enable him again to attend the meetings of the Club. Mr. Bryce drew the attention of workers on the Rotifera to the very valuable collection of drawings that Mr. Rousselet had placed at their disposal. He said that there were among them figures of many forms not described in Hudson and Gosse's work, and urged the members to make use of them.

The Hon. Secretary announced that there would be no meeting on December 25th, and that at the meeting on January 8th

nominations would be received to fill the vacancies on the committee caused by the retirement of the four senior members.

Mr. J. Milton Offord, F.R.M.S., then gave a lantern demonstration on Insects' Eggs. Mr. Offord apologised for giving an address to the Club which contained nothing new, but he thought that the beauty of the eggs was sufficient excuse for his bringing the subject before the members. He drew attention to the remarkable instinct which guides the insects in selecting a suitable place to deposit their eggs, so that the young larva on emerging finds suitable food close at hand. The emergence from the egg is sometimes a matter of considerable difficulty owing to the young larva becoming entangled in the membrane with which the egg is lined. Some insects, earwigs for instance, sit on their eggs, but the speaker was not able to explain why this is done. The eggs of Lepidoptera are generally glued to the leaves of the food plant, those of saw-flies are laid in cuts or crevices of the bark, while the eggs of the bot-fly are laid on the hair of horses so that they may be transferred to the animals' mouths when they lick themselves, and so reach their stomachs where the development is continued.

A series of lantern slides of eggs of various lepidoptera, diptera and avian parasites was then shown on the screen, and although the beautiful iridescence was in some cases lost, the variety of form was well exhibited. The photographs were taken with either a Zeiss Planar or a Zeiss 35-mm. projection lens. The first of the series were the eggs of butterflies, and a great variety of shape and markings was shown. The Cabbage White and the Brimstone lay long eggs rather pointed at one end; they are longitudinally ribbed, and the ribs are connected by crossbars which in the Brimstone's egg are dotted. The eggs of the Chequered Skipper bear similar markings, but are shaped like an orange. Mr. Offord suggested that this ribbing might be for the sake of economy of material, to get as much strength as possible with the amount of material used. The next egg shown, that of the Silver-studded Blue, was quite different; its surface was covered with small tubercles, and its appearance greatly resembled that of the seed of Silene. The eggs of the small Copper again showed a shell apparently strengthened by projecting ridges, but in this case the surface was honeycombed. Mr. Offord then showed some moths' eggs: those of the Swallow-tail were

tub-shaped, while those of the Canary-shouldered Thorn had been compared by some of the men at the Y.M.C.A. huts to petrol-tins, which they very much resemble in shape—both these eggs are brilliantly iridescent. The speaker thought that the egg of the Waved Umber was one of the most beautiful: its surface is honeycombed, and at the corner of each hexagon there is an iridescent pearly boss. The next photograph was of the egg of a fly, Anthomia. These eggs, which are ivory-white, are covered with a fine network of hexagonal markings, and Mr. Offord said that under a high power secondary dottings could be seen similar to those occurring in some of the Diatomaceae—*e.g.*, *Triceratium favus.* The remaining slides were of the curious eggs of bird-parasites. The parasite of the Hornbill lays an egg of an ivory colour with a little cap at one end of it; this egg differs in form according to the position on the feather in which it is laid. The last three slides showed eggs that resembled flowers, that of the parasite of the Japanese turkey being singularly like a chrysanthemum. The chairman proposed a hearty vote of thanks to the speaker, and asked him what form of illumination was used in taking the photographs. Mr. Offord replied that he found a lieberkuhn the best, as it gave a strong light, although better relief was given by using the silvered side-reflector; he used an inverted gas-mantle with the air-pressure carefully adjusted as the source of light. Mr. Bryce said that he was surprised Mr. Offord had kept the photographs so long before showing them to the Club, and Mr. N. E. Brown drew attention to the use of the concave substage-mirror to focus the light on opaque objects, a method of illumination which gave very satisfactory results.

Mr. J. Grundy, F.R.M.S., then continued the address on polarised light which he had started at the previous meeting. He explained how it was that the best results in polarisation were obtained by arranging the object-crystal with its axes at an angle of 45° to those of the crossed Nicols. He then dealt with circular polarisation, and exhibited a portable table-polariscope, and explained how he used it. He also described various simple experiments with the microscope, and demonstrated the passage of a ray of light through one and through two crystals of calcite. Mr. Grundy explained that frequently the light reflected from the sky and from all sorts of objects was polarised, and he exhibited two pieces of apparatus which he used to detect this condition,

which was most frequent after rain at any time of the year. After a hearty vote of thanks had been passed to Mr. Grundy, he explained and demonstrated the use of the various pieces of apparatus he had with him to those interested in the subject.

At the 530th Ordinary Meeting of the Club, held on January 8th, 1918, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on December 11th were read and confirmed.

Messrs. Francis Martin Duncan and Stanley Hirst were balloted for and duly elected members of the Club. Three proposal forms were read for the first time.

The President then read the names of those nominated by the committee as officers for the ensuing year. The election of officers and four members of committee will take place at the annual general meeting on February 12th.

Dr. Rendle then spoke with regard to the proposal to use the British Museum and also the Natural History branch at South Kensington as Government offices. He said that the Government Committee on Accommodation has been considering this question for some time, and that apparently the British Museum will be used by the Air Board. The fate of the Natural History Museum, however, is not yet decided. The collections housed in this building are of great educational value and the public take a lively interest in them. Apart from the useful work done in the exhibited series, there is the priceless collection forming the study or working collection. This collection has been made at great cost and is the result of at least 200 years' labour. Some of the most valuable and fragile things are being put into safe places, but great care is necessary in moving them and in choosing suitable positions. What will happen if the Office of Works undertakes this work ? Many of the collections, moreover, require constant care. It is the duty of the curators to look after them and protect them from the ravages of insects and fungi, and to separate curators from collections is an unthinkable project. The more pressure that is brought to bear on the Government before they make their decision the better. Dr. Rendle then moved the following resolution :

"The Council and members of the Quekett Microscopical Club

hear with consternation and regret of the proposal to utilise a portion of the Natural History branch of the British Museum for Government offices. Such a proposal is in their opinion opposed to the best interests of the nation as threatening serious damage to priceless and irreplaceable scientific specimens, and tending greatly to embarrass the scientific work for the country both now and in the future."

Mr. F. J. Perks, in seconding the resolution, said that if space was required other more suitable buildings might be used ; picture galleries, for instance, where the floor space could be used without disturbing the pictures on the walls. Mr. Perks considered that if the Natural History Museum was used great damage would be done to the collections unless they were treated very differently from the furniture and papers at his office which the Government had occupied.

Mr. R. Paulson, F.L.S., said that shutting up the Museum would mean the shutting up of a great deal of valuable scientific work. In peace time the Museum is a centre for the whole world. Even at the present time work of great value to the community is being done there in connection with the preservation of food, such as biscuits and grain, and the investigation of timber diseases. Quite recently, the Museum staff had suggested a remedy for a fungus which had attacked and destroyed thousands of pounds' worth of army tents in Malta.

The resolution was passed unanimously, and the Secretary was directed to send copies to the Prime Minister and *The Times.*

Mr. J. Milton Offord, F.R.M.S., then gave an address on Mosquitoes and Malaria. The common house gnat (*Culex pipiens*), he said, is a beautiful object for the microscope, and has a most interesting life-history. The eggs are glued together in the form of a raft and are kept in position during oviposition by the crossed hind legs of the female. The raft is unsinkable, and always floats the right way up. The eggs are pointed at the top and flat at the bottom end from which the young larva escapes. The larva is aquatic, but breathes air, and for this purpose it comes to the surface of the water and thrusts its breathing-tube through the surface film. This tube projects from the dorsal surface of the last segment but one, and one or two large tracheae open at its distal end. At the fourth moult the larva changes into a pupa which breathes air in a similar way, but by means of two tubes emerging

from the dorsal surface of the thorax. The perfect gnat emerges from the pupa case while it floats on the water. Culex carries no disease in this country, neither does Stegomyia, but *Anopheles maculipennis*, which is also found in Britain, is the notorious carrier of malaria. Usually there are very few cases of malaria here, but now there are thousands of troops suffering from this disease, and it is very desirable that these men should be placed in districts in which Anopheles is not found until they have recovered. Mr. Offord then described the points of difference between Culex and Anopheles. In the case of Anopheles the eggs are not laid fastened together like a raft. The breathing-tube of the larva is so short that the larva floats in a horizontal position at the surface of the water when breathing, instead of hanging head downwards at an angle of 45 deg., like Culex. The imago has no scales on the body, and the resting positions are very different, Culex resting with the head and tip of the abdomen down and the thorax farthest from the surface it rests on, while Anopheles rests with the head and body almost in a line, the head being down and the tip of the abdomen raised. Mr. Offord then briefly sketched the life-history of the malaria parasite, showing how the sporozoite is introduced into the human blood during the biting of the mosquito, enters a blood corpuscle, and develops into an amoebula, which grows into a rosette and divides into merozoites. The corpuscle then disintegrates, and the free merozoites invade fresh corpuscles. After several cycles merozoites develop into male and female crescents, which undergo no further change until they again enter the stomach of a mosquito, when after further developments an ovum is produced, which elongates and bores through to the outer wall of the stomach, where it forms a cyst. Sporozoites are formed in the cyst, which bursts and they escape, those which reach the salivary glands passing into a human being and starting the cycle again. The lecturer then described the slides and specimens, most of which were very kindly lent by Mr. Lang of the Natural History Museum. He also read some notes which Mr. Lang had written, describing the specimens, and giving some interesting details of the life-history of gnats. Mr. Offord recommended members to notify the Museum of localities where they found specimens of Anopheles, so that they might be avoided by men suffering from malaria.

Mr. James Burton gave an interesting account of the feeding

of an Anopheles larva that he had taken at Epping in July 1913, and stated that he had found two others at Lyon House in August of the same year. Mr. Hilton moved a vote of thanks to Mr. Lang for his kindness in sending the specimens and writing a description of them, which was passed with acclamation, and after some further remarks by Dr. Rodman and Dr. Leeson a hearty vote of thanks was accorded to Mr. Offord for his interesting address. A paper by Mr. E. M. Nelson on "The Measurement of the Magnifying Power of the Microscope" was taken as read.

At the 531st Ordinary Meeting of this Club, held on February 12th, 1917, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on January 8th were read and confirmed.

Messrs. A. Goodman, Benjamin J. Thomas and Arthur H. Niblett were balloted for and duly elected members of the Club. Nomination forms were read for the first time on behalf of four candidates.

The President read the list of nominations for the officers and four members of the committee for the ensuing year. There was very little change, and the nominees were duly elected.

The Secretary read the 52nd annual report, and the Treasurer the balance sheet. Both indicated that the Club's affairs are in a satisfactory position.

Mr. W. R. Traviss exhibited a specimen of the very useful life-slide described by Mr. Banham in the last number of *The English Mechanic*, and also an adapter to enable fairly high-power objectives to be used with a Wenham binocular. The adapter can only be used for such objectives as have the optical system separable from the mount. The end-piece is unscrewed, and the upper part is cut off and drilled out to carry the optical part, which is put in from the top. Mr. Traviss said that a useful substitute for the adapter could be made from the cork from a vinegar bottle, or a strip of paper of suitable length wound round the objective end, so that it might be pushed or screwed into the nose-piece.

The President then delivered his annual address, taking as his subject "The Use of Microscopic Characters in the Systematic Study of the Higher Plants."

The President's address was illustrated by lantern slides, most of which were kindly lent by Dr. Rodman.

Mr. D. J. Scourfield proposed a vote of thanks to Dr. Rendle for his interesting address, and appreciatory remarks were also made by Mr. N. E. Brown and Dr. Leeson.

The President announced the nomination by the committee of Mr. Thos. H. Powell as an honorary member. Mr. Powell is one of the oldest members of the Club, and the announcement was received with acclamation.

The next Ordinary Meeting will be held on March 12th, when there will be a short paper by Mr. C. D. Soar, F.L.S., F.R.M.S., on a Water-mite, *Lebertia sefvei*, and a paper by Mr. G. T. Harris on the moss *Schistostega osmundacea.*

The result of the ballot for the election of officers for the ensuing year was:

For President .	A. B. Rendle, D.Sc., F.R.S., F.L.S.
For Four Vice-Presidents .	Prof. Arthur Dendy, D.Sc., F.R.S., F.L.S. C. F. Rousselet, F.R.M.S. D. J. Scourfield, F.Z.S., F.R.M.S. David Bryce.
For Treasurer .	Frederick J. Perks.
For Secretary .	James Burton.
For Foreign Secretary	C. F. Rousselet, F.R.M.S.
,, *Librarian* .	Alfred George.
,, *Curator* . .	C. J. Sidwell, F.R.M.S.
,, *Editor* . .	A. W. Sheppard, F.R.M.S.

Four members to fill vacancies on Committee:

Mr. N. E. Brown, A.L.S.
Mr. Chas. D. Soar, F.L.S., F.R.M.S.
Mr. C. H. Bestow, F.R.M.S.
Mr. A. Morley Jones.

At the 532nd Ordinary Meeting of the Club, held on March 12th, Vice-President D. J. Scourfield, F.Z.S., F.R.M.S., in the chair, the minutes of the meeting held on February 12th were read and confirmed.

Messrs. E. Doddrell Evens, Basil A. Adams, W. J. Robertson and Edward J. Burrell were balloted for and duly elected members

of the Club. Nomination forms on behalf of three candidates were read for the first time.

The chairman then called upon the Secretary to read Mr. G. T. Harris's paper on *Schistostega osmundacea* Mohr.

After some remarks by Messrs. Scourfield, Grundy, Hinton and Burton, a hearty vote of thanks was accorded to Mr. Harris for his interesting paper. Mr. Scourfield exhibited a specimen of Schistostega in which the luminous appearance was very beautifully shown by means of a vertical illuminator.

Mr. F. J. Perks then read a paper by Messrs. Williamson and Soar on *Lebertia sefvei* Walter. This water-mite is of interest on account of the fact that the species was previously recorded as having been found only in Swedish Lapland. The discovery of the Arctic form in Dartmoor brings the number of the Britannic species of this genus up to twelve. A single specimen of which the sex cannot be determined was taken by Mr. D. J. Scourfield at Fernworthy Bog, Dartmoor, in August 1917.

At the meeting of the Club on April 9th Sir Nicholas Yermaloff, K.C.B., will read a paper, illustrated by lantern slides, entitled "Notes on Some Intermediate Forms of the Genera Cymbella and Navicula."

FIFTY-SECOND ANNUAL REPORT.

In presenting the Report for the year ending December 1917, your Committee feel that though there is some ground for reviewing the work and condition of the Club with less satisfaction than usual, yet taking into consideration the many difficulties caused by the long continuance of the war, the retrospect may be regarded with equanimity, and the future anticipated without anxiety. During the year thirty-four new members were elected, fifteen have resigned, and eight have been lost by death. The present total number is 438. Mr. Alpheus Smith, who was for forty years the Hon. Librarian, and on his retirement, rendered necessary by age and infirmities, was elected an honorary member, died in May, at the age of eighty-seven. Dr. Robert Braithwaite, a past President, and who had been an honorary member since 1893, died in October in his ninety-fourth year. Obituary notices of these two members of the Club will be found in the *Journal*. The death of Mr. Geo. Massee, formerly President, but not a member in recent years, was announced in June. Sir W. H. Lindley, who joined the Club in 1868, and was thus quite one of the older members, but had lived in Germany for many years, has also been removed by death. The Hon. Francis Walter McLaren, M.P., J.P., met his death in August in a flying accident in Scotland.

The attendance at both the Ordinary and Gossip Meetings has somewhat fallen off, which is amply accounted for, not only by the much-restricted service of conveyances and the darkness of the streets, but by the possibility of air raids, as when these occur the almost total stoppage of traffic makes it extremely inconvenient for those living in the suburbs. These difficulties of course particularly affect those of our members who are no longer young, and thus we lose the advantage and pleasure of their presence, which would not happen under more normal conditions. We much regret the continued absence of Mr. C. F. Rousselet

through his serious illness, and are glad to hear at present of some slight improvement in his health. Mr. S. C. Akehurst, who has been Hon. Librarian since 1912, found it necessary in June to resign, owing to his acceptance of an official position in the special constabulary. Mr. Todd, till then Assistant Librarian, consented to take up the responsibilities, and Mr. A. E. Bull was appointed assistant. It was hoped that it would be found possible to supply books from the Library to members living in the country in an efficient way, but almost immediately afterwards Mr. Bull was requisitioned by the military, and had to leave at very short notice. Mr. Alfred George then kindly offered to undertake to carry on the work of Librarian, at least till the end of the year, with Mr. Todd as second. Mr. C. J. Sidwell, who has performed the very exacting duties of Curator most efficiently and unselfishly for many years, found that owing to the unsatisfactory state of his health he was unable to go on with the extra work attending the preparation and issue of a new catalogue of the large number of micro-slides in the Cabinet. It was decided that Mr. Sidwell should be commissioned to obtain any help he found necessary, and that the Club should be responsible for expenses incurred thereby. Mr. Sidwell assented to this arrangement and kindly withdrew his resignation. The almost complete absence of exhibits of new apparatus by the various opticians will be noticed, caused, as in the two previous years, by the fact that their output and energies are entirely taken up with Government work.

It was noticed when the new session began in October that all through the season the Fourth Tuesday in each month—the night of the Ordinary meetings—coincided with the full moon, or within a very few days of it; and as it was believed that air raids were more likely to take place at these times, the Committee decided to change the date of the ordinary meetings to the *second* Tuesday, putting the Gossip night on the *fourth* instead.

A number of the members of the Club have throughout the year—as in the previous year—exhibited microscopic specimens to very numerous audiences of soldiers at the hospitals and Y.M.C.A. huts; these efforts for their entertainment have always been highly appreciated.

The principal communications at the meetings during the year are as follows:

Papers read and Communications made to the Q.M.C. to the End of the Year 1917.

January 23rd.—Mr. David Bryce: On the Collection of the Bdelloid Rotifers. Exhibition of apparatus.

February 27th.—Presidential Address, Prof. Arthur Dendy: The Chessman Spicule of the Genus Latrunculia: a Study in the Origin of Specific Characters.

March 27th.—Mr. A. E. Hilton: On *Trichia affinis*, one of the Mycetozoa. Mr. C. D. Soar: Two New Species of Freshwater Mites. Mr. G. T. Harris: The Desmid Flora of Dartmoor.

April 24th.—Dr. J. Rudd Leeson: On the Common House-Fly, with Especial Reference to its Danger to Health.

May 22nd.—Dr. Alfred B. Rendle: On Colour in Plants and its Preservation. Exhibition of Plants: Specimens for Museums and Herbariums.

June 26th.—Mr. N. E. Brown: Evolution as illustrated by a Genus of Plants. Exhibition of Living Plants.

October 23rd.—Dr. G. H. Rodman: Lantern Demonstration of Photomicrographs, with description and explanation.

November 13th.—Mr. Jas. Grundy: On Polarisation.

December 11th.—Mr. Offord, F.R.M.S., Lantern Demonstration of Insects' Eggs, with description. Mr. Jas. Grundy: Further Remarks on Polarisation, with Exhibition of apparatus illustrative of the various methods.

The Committee desires to thank those who have done so much by their papers and addresses to interest the Club. The delay in the appearance of the *Journal* is the inevitable result of the shortness of labour in the printing trade owing to the war.

The Hon. Secretary of the Excursion Sub-Committee reports that the excursions were very satisfactory. Nine were arranged for, and the average attendance was 20·9, a higher figure than in the two previous years. Although nothing unusual in the way of finds was recorded, much interesting material was obtained, and the junior members benefited by the experience of those more expert in the practice of pond-hunting. The visit to the Royal Botanic Gardens, Regent's Park, in April showed how greatly this excursion is appreciated, forty-two members being present, and the thanks of the Club are due to the Royal Botanical Society for their kindness in admitting the visitors. Thanks are

also due to Sir Philip Sassoon for the privilege of collecting in the ponds in Trent Park.

On the occasion of the excursion to Hampton Court the members were entertained to tea by Dr. and Mrs. Leeson; at the Greenford and Ealing excursion Mr. and Mrs. Offord showed their hospitality for the third time; and Mr. and Mrs. Wilson performed the same kind action on the occasion of the Richmond Park outing. Dr. Measures undertook the expense for the requisite meal at Waltham Abbey; and Mr. Tilling performed the same kind office at Higham's Park. All these friends and members of the Club have earned the gratitude of the excursionists for these very welcome services.

The list of books and pamphlets, etc., added to the Library since the end of April of last year was as follows:

List of Books, Journals, Reports, etc., received during the Year.

Books.

Plant Teratology. Vol. II. Ray Society.
Purchased.

Quain's Anatomy. Vols. I and II.
Presented by Dr. G. Burton Brown.

Histology of Medicinal Plants.
Mansfield. *Presented by the Publishers.*

Guide to the Exhibited Series of Insects.
Dept. of Zoology, Brit. Museum (Nat. Hist.) *Presented.*

Récherches sur les Rotifères.
Beauchamp. *Purchased.*

Journals, Reports, etc.

American Microscopical Society. Vol. XXXV., Nos. 3, 4—Vol. XXXVI., Nos. 1, 2.

Academy Natural Sciences. Philadelphia. Vol. LXIX., Part 1.

British Association, Report of. Newcastle, 1916.

Brighton and Hove Natural History Society, Annual Report, June 1916, July 1917.

Bristol Naturalists' Society, Annual Reports and Proceedings. 1912–13–14–15.

Bergens Museum Aarbok. 1914–15. Pt. 3—1915–16, Pts. 1, 2.
Bergens Museum Aarsberetning. 1914–15—1915–16.
Croydon Natural History Society. Vol. VIII., Pt. 3.
Edinburgh, Botanical Society of. Vol. XXVII., Pt. 1.
Glasgow Naturalist. Vol. VIII., Nos. 1, 2.
Geologists' Association. Vol. XXVIII., Pts. 1, 2, 3.
Hastings and East Sussex Naturalist. Vol. II., No. 6.
Hertfordshire Natural History Society. Vol. XVI., Pts. 3, 4.
Illinois Biolog. Monographs. Vol. II., No. 4.
Missouri Botanical Gardens, Annals of. Vol. III., Nos. 2, 3, 4—Vol. IV. Nos. 1, 2.
Manchester Literary and Philosophical Society. Vol. LXI., Pt. 1.
Manchester Microscopical Society, Annual Report. 1916.
Photomicrographic Society. Vol. V., No. 3. Vol. VI., Nos. 1. 2.
Philippine Journal of Science :

Section	A.	Vol.	XI., Nos. 4, 5, 6.
		,,	XII., Nos. 1, 2.
,,	B.	Vol.	XI., Nos. 5, 6.
		,,	XII., Nos. 1, 2, 3, 4, 5.
,,	C.	Vol.	XI., Nos. 4, 5, 6.
		,,	XII., Nos. 1, 2, 3, 4, 5.
,,	D.	Vol.	XII. Nos. 1, 2, 3.

Quarterly Journal Microscopical Science. Vol. LXII., Pts. 2, 3.
Q. M. C. Journal. Vol. XIII., Nos. 78, 79.
Royal Society. Vol. LXXXIX. B. 618, 620, 621, 622, 623, 624, 625.
Royal Society New South Wales. Vol. L., Pts. 2, 3.
Royal Microscopical Society Journal, 1917. Pts. 1, 2, 3, 4, 5, 6.
Royal Dublin Society, Proceedings. Vol. XV., Nos. 15, 16, 17, 18, 19, 20, 21, 22, 23. *Economics.* Vol. II., Nos. 12, 13.
Redia. Vol. XII., Pts. 1, 2.
Torquay Natural History Society. Vol. II., No. 3.
U.S. National Museum. Bulletins. Nos. 71, Pt. 6—93, 95, 96, 98–100. Vol. I., Pt. 1, 101, 102, Pts. 1, 2, 3.
U.S. National Herbarium. Vol. XVIII., Pts. 5, 6, 7. Vol. XX., Pts. 1, 2.
Victorian Naturalist. Vol. XXXIII., Nos. 8, 9, 10, 11, 12—Vol. XXXIV., Nos. 3, 4, 5
Wisconsin Academy. Vol. XVIII., Pt. 2.

The Hon. Curator reports that the number of slides lent to members has been quite up to the average. Slides to the number of 155 have been added to the Cabinets by Mr. C. F. Rousselet, who has again increased the Club's indebtedness to him by placing at its disposal his miscellaneous preparations. During the year the Club has been presented with a complete Zeiss microscope and apparatus from Mr. Ingpen. This was originally presented to him as a testimonial by the Club some thirty years ago.

Amongst the apparatus is an Abbe apertometer, which should prove useful to any member desirous of measuring the numerical aperture of his objectives. The collection of slides is undergoing thorough revision, and a manuscript catalogue is in course of preparation, with the view to its being printed after the war. The thanks of the Committee are due to Messrs. Bestow & Gardner for assistance rendered to the Curator in the issue of slides, and also to Mr. J. M. Offord for kindly officiating with the lantern.

Mr. L. C. Bennett has continued the valuable help he has given the Club for several years, in making welcome visitors and newly elected members at the meetings, and the Committee tender him their thanks for this very useful service.

The Committee feel sure that members will join with them in thanking the officers for their zeal in carrying on the necessary work of the Club, under circumstances which make it particularly trying and arduous, and they desire to call upon all to second these efforts with the object of securing the continued success and prosperity of the Quekett Microscopical Club.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1917.

Dr.	£	s.	d.	Cr.	£	s.	d
To Balance from 1916	118	11	0	By Rent	75	0	0
,, Subscriptions	193	0	0	,, Expenses of *Journal*	146	3	9
,, 1 Life Composition	10	0	0	,, Postages, etc.	2	7	2
,, Dividends on Investments	14	5	4	,, Printing and Stationery	9	5	9
,, Sales of Journal	40	3	8	,, Attendant	7	3	4
,, Advertisements	5	6	6	,, Petty Expenses	1	3	6
,, Catalogues	0	2	0	,, Books and Slides	23	15	5
				,, *English Mechanic*	7	8	2
				,, Balance in hand	109	1	5
	£381	8	6		£381	8	6

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	334	1	6
Metropolitan Water Board Stock	100	0	0
Metropolitan Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

January 22nd, 1918.

J. WILSON
ALFRED E. HILTON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

TABLE FOR THE CONVERSION OF ENGLISH AND METRICAL LINEAR MEASURES; YARD AND METRE AT SAME TEMPERATURE.

1 ÷	mm.	1 ÷	μ	1 ÷	μ	1 ÷	μ	1 ÷	μ
2	12·70	27	940	53	479	79	321	125	203
3	8·46	28	907	54	470	80	317	130	195
4	6·35	29	876	55	462	81	313	135	188
5	5·08	30	846	56	453	82	310	140	181
6	4·23	31	819	57	445	83	306	145	175
7	3·63	32	794	58	438	84	302	150	169
8	3·17	33	769	59	430	85	299	155	164
9	2·82	34	747	60	423	86	295	160	159
10	2·54	35	725	61	416	87	292	165	154
11	2·31	36	705	62	410	88	289	170	149
12	2·12	37	686	63	403	89	285	175	145
13	1·95	38	668	64	397	90	282	180	141
14	1·81	39	651	65	391	91	279	185	137
15	1·69	40	635	66	385	92	276	190	134
16	1·59	41	619	67	379	93	273	195	130
17	1·49	42	605	68	373	94	270	200	127
18	1·41	43	591	69	368	95	267	205	124
19	1·34	44	577	70	363	96	265	210	121
20	1·27	45	564	71	358	97	262	215	118
21	1·21	46	552	72	353	98	259	220	115
22	1·15	47	540	73	348	99	256	225	113
23	1·10	48	529	74	343	100	254	230	110
24	1·06	49	518	75	339	105	242	235	108
25	1·02	50	508	76	334	110	231	240	106
	μ	51	498	77	330	115	221	245	104
26	977	52	488	78	326	120	212	250	102

As the measurements of many microscopical objects are given in fractions of an inch in English literature, and in metrical measure in foreign works, the above table has been drawn up to facilitate comparison. Its use is obvious. Examples: 1/7th inch = 3·63 mm., 1/58th inch = 438 μ, or ·438 mm. For fractions smaller than 1/250th inch that portion of the table between the figures 26 and 99 may be used by cutting off the last figure for hundredths, and the two last figures for thousandths. Examples: 1/270th inch = 94·0 μ, or ·0940 mm.; 1/7900th inch = 3·21 μ, or ·00321 mm. When that portion of the table between the figures 100 and 250 is used it is only necessary to cut off the last figure for thousandths and the two last figures for ten thousandths. Examples: 1/1350th inch = 18·8 μ, or ·0188 mm., 1/16500th inch = 1·54 μ, or ·00154 mm. The conversion of millimetres into fractions of an inch is performed in the same manner; thus, 529 μ or ·529 mm. = 1/48th inch; 39·7 μ or ·0397 mm. = 1/640th inch; 2·62 μ or ·00262 mm. = 1/9700th inch; 1·04 μ or ·00104 mm. = 1/24500th inch; ·977 μ or ·000977 mm. = 1/26000th inch, and so on.—E. M. N.

NOTES ON SOME INTERMEDIATE FORMS OF THE GENERA NAVICULA AND CYMBELLA.

By Sir Nicholas Yermoloff, K.C.B., K.C.V.O., F.R.M.S,

(*Read April 9th,* 1918.)

Plates 26–28.

All students of Diatoms are invariably impressed by the immense number of individual forms, species, sub-species and varieties patiently noted, described, named and classified. The differences of diagnosis which have led to the creation of new forms are undoubtedly sometimes very trifling and uncertain, based upon personal impressions of observers, and, together with the enormous multiplication of forms, there has arisen a veritable labyrinth of confused synonymy.

From time to time, distinguished authors have tried to remedy this state of things and to put some order in this chaos, striving to reduce the existing number of admitted species and varieties, and basing the regrouping they proposed, not so much on individual variations as upon similarities of forms. Such regroupings have been attempted by Cleve as regards the genus Navicula, by Cox and Rattray as regards Coscinodiscus.

It cannot be admitted that these attempts have until now proved very successful and fruitful. On the pages of one of such recent reformers we read : "The reduction of the enormous catalogues of species of Diatomaceae is a consummation devoutly to be wished."

Well, perhaps I am mistaken, but I am not so sure that this consummation is so devoutly to be wished as all that : it seems to me that the admirably patient and careful labour of registering minutiae, and the consequent subdivision of species, has been both fruitful and inevitable. It has been—to borrow a term from higher mathematics—a process of "differentiation," a study and investigation of the elemental variations of the so-called

"variable." No reverse process of synthetic grouping, or, if I may again use a term of mathematics, no process of "integration" is possible and thinkable without the previous exhaustive examination of the elemental "differentials." It would therefore seem to me that the consummation devoutly to be wished would lie in another direction—not in the curtailing of the differentiating operations, but in a process of reverse character, namely, in a process of synthetic integration, undertaken after the study of variations had been thoroughly mastered. This reverse process ought to be performed, as is again done in mathematics, according to some definite method and plan within certain limits.

One of your illustrious writers has truly said: "Ill can he rule the great that cannot reach the small." Nothing is more true in a scientific sense: before undertaking any work of integration we must thoroughly master variation in all its forms.

To return to Diatoms, it is to be noted that the variations of intermediate forms by no means appear as a rule to be abrupt; on the contrary, they are usually very gradual, and, I should say, continuous, insensibly passing from one form into another. But that peculiarity in Nature is most precious, and immediately gives us guidance as to how to proceed farther: on the one hand it leads us towards Darwin's doctrines of Evolution; on the other hand it brings the study of a biological subject closer to the ideas of abstract mathematics.

The work of synthetic integration I am speaking about cannot of course be done, so to say, accidentally or at random: it must be done according to some guiding idea, and must follow some definite formula or plan. At the present stage of diatom systematics it is perhaps feasible to make an attempt in that direction. Such an attempt, however small, forms the subject of this paper.

In the course of my paper I shall have occasion to explain that a certain fossil Diatom, found in the freshwater deposits of the American State of Maine—*Navicula Monmouthiana*—may be considered as an ancestral form of a whole series of species of Cymbella which I am about to describe. It would seem that this ancestral form, through the course of many centuries, had passed through a long series of many slight transformations, evolving about fifteen forms of Cymbella extremely near and similar to each other, and closing the series in a very small form, *Cymbella*

microcephala, which I will also describe. If we go down or up this ladder we shall see how insensibly the intermediate forms pass from one into another.

Now before I proceed along this ladder I should like to state that the majority of freshwater Diatoms as a rule favour cold climates, cold waters, cold mountainous streams. It has been even ascertained that the higher the altitudes they are found in, the more they thrive and the more pronounced and dense are their markings. It would seem therefore natural to suppose that the parental fossil form I am speaking about, *Navicula Monmouthiana*, appeared on the scene in the State of Maine, at the latitude of 45 degrees north, in other words at the latitude of the Great Lakes of Canada, about the end of the Pliocene period, just about the beginning of the Glacial epochs. At that time, as is admitted by geologists, the continent which connected North America with Europe—the so-called Atlantis—under the influence of volcanic action began to break up, opening into more southern seas a passage for the colder waters of the Polar regions, and bringing down the great glacial deposits of ice as far south as the Great Lakes. At that time the climatic conditions on our earth began to undergo great and important changes: until then the uniformly tropical climates prevailing much farther north than the 45th parallel were beginning to cool and to give way to colder conditions, heralding in the Glacial epochs. It was at the end of the Pliocene that the large proboscidian mammals began also to disappear from high latitudes, or at least that some of them began, like the mammoths, to have fur coats. It was after the end of the Glacial epochs, and with the advent on our planet of temperate climates, that there began also the distribution of the Angiosperm Flora, resulting in the differentiation of the many groups of modern vegetation. It would therefore be natural to suppose that about the end of the Glacial periods the parental form, *Navicula Monmouthiana*, started upon its path of variations, evolving the many descendant forms I am about to describe. If we admit that this work of evolution started on its way after the disappearance from the regions of the Great Canadian Lakes of the last ice sheet of the Glacial epoch, we could reasonably assign for it the whole of the Quarternary period up to the present day.

In the light of the comparison with higher mathematics with which I began my paper, we may suppose *Navicula Monmouth-*

iana to be a sort of "integral" to begin with, and the *Cymbella microcephala* the last "derived function" of the series. Indeed, we may say that Nature herself is a great and patient mathematician, one whose integrals are primordial forms and whose derived functions are what naturalists call "species." And from this point of view it would perhaps be permissible to introduce, I should not say a new, but a different definition of what in natural history is meant by the word "species": it is a definition which was advocated in Russian scientific circles before the war:

"A species in Nature corresponds to what in the Differential Calculus is meant by a 'derived function': it is a certain type-limit, to which tend, without even sometimes quite identically attaining it, certain varying intermediate forms."

The distinguishing features upon which are founded the systematic classification of Diatoms belong to seven categories:

(1) *Habitat.*—Whether freshwater, brackish water or marine. This is a very constant and definite feature.

(2) *Modus vivendi.*—Whether free, stipitate, enclosed in mucilaginous tubes, living individually, or in colonies, bands, chains and the like. This is a very uncertain and changeable feature of distinction.

(3) *Size.*—A fairly constant feature within certain limits.

(4) *Exterior structure* of the valves as to: raphe, nodules, costae or striae, also as to hyaline axial and central zones. This is a very important category, liable to many variations, yet usually constant within certain limits.

(5) *Interior structure* and arrangements: septa, loculi, zone details in the frustule view.

(6) *Outline form* of the valves, of the margins and ends. A most important category of distinctive features.

(7) *The distribution of the endochrome* as regards chromatophores, pyrenoids, etc.

All the above seven categories are important for the determination of forms, but not equally so. Some are more, some are less, constant and reliable. To show how careful the observer has to be even with such a comparatively constant distinctive feature as *habitat*, whether a diatom is freshwater, brackish water or marine, I will state the case of the so-called *Fragillaria antarctica.* Now nearly all Fragillariae are freshwater. Yet *Fragillaria*

antarctica is found in enormous numbers in slides from the bottom of the Antarctic Ocean at a depth of 2,000 fathoms. How did it get there? The explanation was given by my late much-lamented friend, Sir John Murray. It is this: *Fragillaria antarctica*, a freshwater diatom, lives in huge quantities on the Antarctic lands. It is carried away on floes of ice to the open sea, and when the ice melts or breaks up it floats in the ocean as a pelagic plankton, and when it dies, its skeleton falls down to the sea bed, where it goes to form a Diatom Ooze, and where it was found in abundance by the soundings of H.M.S. *Challenger*. As a general rule, it is in structure, size and outline that the systematist has chiefly to guide himself for the determination of species and varieties. It is therefore also in structure, size and outline that we have to seek for some guiding principle as to synthetic integration.

The main line upon which it would be perhaps possible to look out for synthetic grouping would seem to lie in a close study of undoubtedly intermediate forms, and in an effort to detect affinities between them, seeking a disclosure in these relationships of what may be called "descendancy" or "lineage" evolved through time and ages. Fossil and living forms are to be closely compared and connected with one another. We must try to guide our systematic studies by "genealogical descent."

In Volume I of the standard *Synopsis of Naviculoid Diatoms*, by Cleve (p. 157), is to be found a hint how to approach this problem. There the author seeks to establish two lines of genealogical descent as regards several species of the genus Cymbella. His hint seemed to me most promising and fruitful, and I have tried to pursue it farther, taking up not the genus Cymbella as a whole, but only some of its tribes. I have tried to establish connecting links within certain limits, showing how intermediate forms seem to pass one into another as regards structure, outline and size.

In his book Professor Cleve traces relationships between species of Cymbella along two genealogic lines, starting in one case from *Navicula dicephala*, and in the other from a marine Navicula, *Navicula Bulnheimii*. I have taken up his second line and tried to trace a passage from and connection between about a dozen species, sketches and microphotographs of which accompany this paper. I do not, however, include in my series the *Navicula*

Bulnheimii, which is a marine form, whereas all the forms of my study are freshwater. I moreover begin my series with the form which appears to be the ancestral parental one, *Navicula Monmouthiana*.

The genealogical series which I am about to describe runs in the following order. Here I should like to make the following remark: it is hardly desirable that so-called intermediate forms should receive special names; it would seem better to give them so-called "hyphenated" nominations, stating the initial form from which they seem to start, and the final form to which they appear to tend. Thus, a form intermediate between *Monmouthiana* and *Stodderi* ought to be named thus: *Monmouthiana-Stodderi*.

The series runs as follows:

1. *Navicula Monmouthiana* Grun.
2. *Navicula Monmouthiana* Grun.
3. *Navicula Monmouthiana-Stodderi*.
4. *Cymbella Stodderi* Cleve.
5. *Cymbella Stodderi* Cleve.
6. *Cymbella aequalis* W. Sm.
7. *Cymbella aequalis* W. Sm.
8. *Cymbella angustata* W. Sm.
9. *Encyonema gracilis* Rabh.
10. *Encyonema Scotica* W. Sm.
11. *Cymbella delicatula* Kütz.
12. *Cymbella gracilis-Cesatii*.
13. *Cymbella Cesatii* Rabh.
14. *Cymbella microcephala* Grun.

This series could be arranged under one heading which, for the purpose of this paper, I would style the "Monmouthiana Integral" (Plate 26).

Although the series begins with *Navicula Monmouthiana* and ends with *Cymbella microcephala*, yet I will, in order to follow Cleve, describe the different species in the reverse sequence, beginning with *Cymbella microcephala*. The sketches and microphotographs accompanying this paper have been taken from four slides, two from Europe (St. Fiore, Italy, and Premnay Peat, Scotland) and two from North America (Herkimer in the State of New York and Monmouth-Cherryfield in the State of Maine).

I may mention here that Herkimer is a small town on the River Mohawk, a mountainous stream cutting its way through a spur of the Adirondacks, just a place for Cymbellae to live in, it being well known that Cymbellae as a rule much favour clear mountainous streams in alpine regions. And in reality the Herkimer slide is full of various Cymbellae.

The Monmouth-Cherryfield slides contain fossil forms; both these places are small towns in the State of Maine, not far from the Atlantic coast on the line from Portland to Bangor, at about 43° N. This is interesting, as it seems that a relationship can be traced between the Herkimer Cymbellae and the fossil forms of the Maine deposits. Indeed, according to Cleve, some of the Herkimer species, as for instance *Cymbella Stodderi*, are also to be found in the White Mountains in the State of New Hampshire, nearly at the same latitude between the Adirondacks and the State of Maine. Before entering into specific details I would mention that the Cymbellae described all belong to the "narrow" or "naviculoid" type, very slightly asymmetric, and with both margins convex. Some belong to the Encyonema group, living in gelatinous tubes and with terminal nodules distant from the ends—the chief characteristic of this group.

The generic characteristics of the genus Cymbella are too well known to be repeated here. I would add only a few remarks:

(1) As far as I am able to observe, the central nodule, being eccentric, may lie either on the ventral or on the dorsal side.

(2) The terminal fissures are comma-like, and are turned in the same direction, opposed to the side on which lies the central nodule.

(3) The raphe towards the ends seems to be always a little arcuate or oblique, but towards the central nodule appears as if it were slightly thickened, or as if it were approaching the upper surface of the valve from below. Under low powers the oblique part is usually invisible, but the thickened part is always seen. This view is very characteristic of Cymbellae, even in the smallest and least asymmetrical individuals. It is sometimes observable even in those Naviculae which are intermediate to Cymbellae.

(4) Some of the forms which I am going to describe show on the median striae a punctum or stigma, more or less distinct. This stigma causes the median stria to appear as if it coalesced with the central nodule. According to van Heurck, this peculiarity

is well known and recorded as regards *Encyonema Scotica* and perhaps *Encyonema gracilis*, but it does not seem to have been noted as regards *Cymbella Cesatii.* Yet there it is. There is therefore reason to admit that those forms which possess the stigma are intermediate between *Encyonema gracilis* and *Cymbella Cesatii.* Not wishing to multiply names, I have, for convenience' sake, noted such forms with the stigma as *Encyonema gracilis-Cesatii.*

(5) The forms which I have sketched and photographed as *Cymbella* (*Encyonema*) *gracilis-Cesatii* in the Herkimer slide may be a new species. I have nowhere found a correct description of them. Apart from the peculiar stigma they show other peculiar features: their outline is more or less rhomboidal, and on some individuals very cymbelloid, or rather bent along the longitudinal axis. The terminal nodules are always distant. They are very narrow. The stigma gives them a false appearance of *Gomphonema*, yet the striae are so radiate that they have not the facies of a *Gomphonema.*

(6) Some of the forms I am about to describe have a decided tendency to triundulate margins, or at least one of the margins shows triundulation. Whether it is a specific characteristic or an intermediate one I cannot say, but anyhow *Cymbella angustata* is stated by Cleve to be slightly triundulate, and so it is. But slight triundulation is noticeable also in *Cymbella Cesatii*, the forms sketched as *Encyonema gracilis-Cesatii*, and also in the robust *Encyonema gracilis* of the Monmouth-Cherryfield deposits. These, however, have nowhere been recorded in existing descriptions as regularly triundulate. I am inclined, therefore, to consider such triundulation as a sort of transitional characteristic, appearing on intermediate forms. I wonder whether as a rule there may not be characteristics which ought not to be described as "specific," but rather, and only, as "transitional," *i.e.* as belonging only to intermediate forms.

(7) As regards hyaline areas (axial and central) these as a rule are more developed on American than on European specimens.

(8) The majority of forms in the Monmouth-Cherryfield slides, which look very much like *Navicula Monmouthiana*, nevertheless do not appear to be quite identical with the type form of *Navicula Monmouthiana.* I will point out the difference at the conclusion of my paper.

The Genealogical Ladder

Cymbella microcephala (Plate 28, figs. 18, 19).

This small Cymbella is common in European deposits. The striae are very faint and dense (25 to 0·01 mm.), parallel. The ends are rostrate-capitate. The areas indistinct. The outline slightly asymmetrical. Length about 0·03 mm. The typical form is a little smaller and broader than the one figured on the sketches. The characteristic features are: the parallelism of the striae and the absence of areas.

Cymbella Cesatii (Plate 28, fig. 17).

I doubt whether this curious diatom ought not to come much higher up the genealogical scale, anyway after *Cymbella angustata.* I place it here only to follow Cleve. It has been assigned to three genera: to Cymbella, to Encyonema, and to Navicula. It is very narrow and nearly symmetrical. Its chief characteristic is the distant terminal nodules. The ends are more or less acute. Areas indistinct, but the central area is sometimes slightly rounded. The margins begin undoubtedly to show a tendency to triundulation, a feature which seems to be transitional to the next form of our series.

Cymbella gracilis-Cesatii (Plate 28, figs. 14, 15, 16).

This is a very curious form in the Herkimer slide, where it is fairly numerous, showing rather variable outlines. The areas begin to be distinct. The terminal nodules are distant from the ends, perhaps even more so than in *Cymbella Cesatii.* It is rhomboidal and sometimes cymbelloid, bent along the longitudinal axis. The striae are radiate, though not so radiate as in *Cymbella Cesatii*, and not so dense. It usually shows on the median striae a distinct stigma. This gives it a false appearance of a *Gomphonema.* It is shorter than *Cymbella Cesatii* and still more slender. As I have already mentioned, this may be a new species.

Cymbella delicatula (Plate 28, fig. 13).

This form is very similar to the next one, but it is not an Encyonema. The terminal nodules are not distant and the ends are acute. The Rev. Wm. Smith points out that it comes very near to *Encyonema Scotica*, and so it does.

Encyonema Scotica (Plate 28, fig. 12).

This form is common both in European and American deposits. It is too well known to need description. The striae are less dense and the areas more distinct.

Encyonema gracilis (Plate 27, fig. 10; Plate 28, fig. 11).

I describe here only those specimens of this species which are fossil in the Monmouth and Cherryfield slides. I think I have made no mistake in the determination, but I am not quite sure: it comes also very near to *Cymbella Yarrensis*, figured in Schmidt's Atlas. On the other hand Cleve states that *Cymbella Yarrensis* is a native of Australia and Tasmania, and I am rather averse to identifying a fossil form from North America with a living one from southern waters. The specimens are rather large and robust, the striae pronounced, radiate but parallel at the ends. Axial area very regularly linear. Ends acute with slightly distant terminal nodules. Tendency to triundulation slight but appreciable. No distinct stigma, but on some specimens there is something like an indistinct stigma. Striae moniliform slightly decipient. Length as large as 0·07 mm., or even more, therefore these American fossil specimens are longer than stated by Cleve, who gives as maximum length 0·056 mm. Striae visible even under low power. The number of striae to 0·01 mm. seems identical with the one stated by Cleve: 13 to 0·01 mm. or a little more.

Cymbella angustata (Plate 27, fig. 9).

This is a very important member of our series. It is found both in European and American slides. The striae are faint, radiate, about 16 to 0·01 mm. Ends rostrate-capitate. Margins usually triundulate. Areas narrow but distinct, and in forms intermediate to *Cymbella Stodderi* showing a tendency to become broader.

About this species there seems to have arisen in the works of authors some confusion: on Plate XVII, fig. 156, of the *Synopsis of British Diatomaceae*, the Rev. Wm. Smith gives a fairly good drawing of it, but calls it *Navicula angustata*, which is natural enough owing to its nearly symmetrical outline. He does not show any striae. But the whole habit of the species seems

very true to nature. It seems to be undoubtedly *Cymbella angustata*.

Further, according to Cleve and to van Heurck, it has been somehow mixed up with *Cymbella aequalis* or *subaequalis*, and that seems more inexplicable, seeing that the so-called *aequalis* group, although very akin to *angustata*, is yet different enough.

Cymbella angustata is undoubtedly a form steadily passing, perhaps through the *aequalis* group, into the American *Cymbella Stodderi*—a living form characterised by rostrate or subrostrate ends, broader areas and punctate striae.

Cymbella aequalis and subaequalis (Plate 27, figs. 7, 8).

These two forms are so near to each other that it is almost impossible to distinguish them, and indeed Cleve simply unites them together into one species. There seems to be a difference between them only in the dimensions of the axial area and perhaps in size. Both these forms have the same chief specific feature, which is that the median striae are farther apart (decipient). Both are rather distinctly asymmetrical, and the ends are rather obtuse. Both are common in Europe. I should say that in America they pass into *Cymbella Stodderi*, but their striae are always much less distinctly punctate. The *aequalis* group is very numerous in the St. Fiore slide, where it shows some insignificant variations. One of such varieties has been styled by Grunow var. *Florentina*, but it seems hardly to deserve a special name. All these forms are small, not more than 0·04 mm. in length. The striation is not so dense as in the American forms. The whole group seems to be very akin, on one side to the *angustata* group, on the other to *Cymbella Stodderi*. I have therefore placed the *aequalis* group in the genealogical table as intermediate between the *angustata* and the *Stodderi* groups.

Cymbella Stodderi (Plate 27, figs. 5, 6).

This species is most interesting from our point of view. It is to be found on the Herkimer slide in profusion. Cleve states that it also inhabits the White Mountains. It is nearly symmetrical, yet still a Cymbella. It has subrostrate ends. The striae are very punctate, radiate, numbering about 15 or 16 to 0·01 mm. I cannot understand why Cleve says that it is not distinctly punctate. On the contrary it is, at least on the Herkimer speci-

mens, very clearly punctate. Its chief distinctive feature is the area, which is linear-lanceolate, more or less linear and more or less lanceolate. The Rev. Francis Wolle, in his *Diatomaceae of North America*, gives a figure of it on Plate LXIII, fig. 34, but this figure is not good: it is too broad, too naviculoid, and the ends are too rostrate. The area is shown too broad. However, there seems to be no other figure extant. Cleve mentions a very true and very important fact: that *Cymbella Stodderi* is nearly akin to *Navicula Monmouthiana*, and so it undoubtedly is. In fact, as soon as *Cymbella Stodderi* loses the subrostration of its ends and the lanceolate outline of its area, it merges immediately into *Navicula Monmouthiana*.

Navicula Monmouthiana-Stodderi (Plate 27, figs. 3, 4).

This is a form intermediate between *Cymbella Stodderi* and *Navicula Monmouthiana*. The evolutionary transition from a Navicula to a Cymbella is already well marked: the valves have acquired asymmetry and a slight tendency to subrostration. The striae are more punctate and the axial area is broader and more lanceolate than on *Cymbella Stodderi*.

I now come to the final member of the whole series I have examined, to *Navicula Monmouthiana*.

As I have already stated, this last term of the series seems to me to be the prototype of them all, I mean the type to which all the others are, so to say, pointing. In my opinion, it is the ancestral Pliocene form. We ought, therefore, not to climb up to it from *Cymbella microcephala*, but on the contrary descend the ladder in the opposite direction, admitting *Monmouthiana* as the first, and *microcephala* as the last, member of the series. In my opinion, *Navicula Monmouthiana* seems to have been the fossil ancestral parent, from which the whole tribe has derived if not to say degenerated. Now it is well known that several authors admit that Cymbellae are degenerate Naviculae. This admission seems plausible. I do not like to use the term "degenerate," because we cannot know the trend and direction of evolution, yet it appears quite natural to admit that *Navicula Monmouthiana* is, so to say, a perfect form, whereas the Cymbellae are imperfect forms.

Navicula Monmouthiana (Plate 27, figs. 1, 2).

This curious fossil diatom is fusiform. Its average length is about 0·07 mm. Its breadth about 0·01 mm. Striae very dense, parallel in the middle, then radiate up to the ends. The ends not protracted. Number of striae 16 to 20 to 0·01 mm. As all Entoleiae Naviculae, it has rather convex valves. Fissures comma-like turned in the same direction. Pores rather distant. The axial area is regularly linear, or I should rather say parallel to the margins.

Such is the typical form of *Navicula Monmouthiana*. This type form is rare: the great majority of the *Monmouthiana* forms on my Monmouth-Cherryfield slides are slightly different, already showing a first variation from the type form. Although identical with it in everything else, yet there is this difference, that the outline or contour of the axial area is not regularly linear, but linear-lanceolate; up to the half of the distance between the ends and the central nodule this area is linear; then it gets elongated and becomes lanceolate. This difference can hardly be considered unimportant or accidental, because on all such specimens it is invariably constant.

Now a lanceolate outline of the axial area is a feature peculiar to, and very constant in, *Cymbella Stodderi*. On the other hand the *Stodderi* forms are always subrostrate, whereas *Monmouthiana* never shows any subrostration at all. I am therefore much inclined to admit that the *Monmouthiana* forms I am speaking about are not exactly *N. Monmouthiana*, but an intermediate form between *N. Monmouthiana* and *Cymbella Stodderi*. And from this point of view they are the more interesting, as they represent an intermediate variation: although very near to the typical *Monmouthiana*, yet they have so to say already moved towards the associated variety, the *N. Monmouthiana-Stodderi*.

We have thus travelled, step by step, through the whole series of these forms, which, beginning with *Navicula Monmouthiana*, ends with *Cymbella microcephala*, and which I have proposed to group under the name of the "Monmouthiana Integral." This whole group includes many species and varieties, yet they are so nearly connected with one another that it is hardly possible to say where one ends and the other begins.

Along the path of the evolution we actually note the following gradual changes:

(1) The ancestral fossil form, *N. Monmouthiana*, is large, symmetrical, showing no rostration. Its axial area is broad and regular. The striation is dense and punctate. From a geometrical point of view the form is, so to say, perfect.

(2) Then the striation becomes less and less pronounced and dense, and less and less visibly punctate or lineolate. The areas appear less and less regular and become narrower.

(3) Although none of the forms show any pronounced asymmetry, yet they become more and more asymmetrical, actual Naviculae transforming themselves into Cymbellae.

(4) The forms seem to gradually acquire first rostrate, then even capitate ends.

(5) The forms gradually become reduced in size.

(6) At the end of the series, *Cymbella microcephala* shows no hyaline area at all. It is of very small size, has rostrate-capitate ends and very faint striae.

Such seems to have been the march of evolution and of changes in the forms. The naviculoid form seems to have lost its perfect outline and become a Cymbella, losing symmetry and size and acquiring, perhaps at the expense of striation, differences in the shapes of the ends. I am therefore strongly inclined to think that indeed the whole process has been a sort of "degeneration" from a simple and perfect form to varied and complex forms. I again repeat that I do not like to use the term "degeneration," because we cannot know the trend of evolution. I therefore use this term only for convenience sake.

After all, the above trend of changes seems to be natural enough, being perhaps a logical and inevitable result of the more complex conditions of life appearing on our planet and establishing themselves on the globe after the Glacial periods. After all, the same trend of changes, from large, uniform and simpler forms to smaller, more varied and more complex ones, seems to have affected the whole of organic life. No wonder therefore that the same trend has wrought similar changes in Diatoms. It has actually been a transition from homogeneous to heterogeneous forms.

Thus a minute study of systematics seems to have helped us on towards regions of generalisation. I therefore consider that systematics are certainly not the dry and useless work they seem

to some: on the contrary, they are necessary, and fruitful of larger results, and every Systematist, with his minute and laborious examinations, brings his contribution towards the construction of the great building of scientific knowledge.

Description of Plates 26–28.

Plate 26.

Fig. 1. *Navicula Monmouthiana* Grun.
,, 2. *Navicula Monmouthiana* Grun.
,, 3. *Navicula Monmouthiana-Stodderi.*
,, 4. *Cymbella Stodderi* Cleve.
,, 5. *Cymbella Stodderi* Cleve.
,, 6. *Cymbella aequalis* W. Sm.
,, 7. *Cymbella aequalis* W. Sm.
,, 8. *Cymbella angustata* W. Sm.
,, 9. *Cymbella* (*Encyonema*) *gracilis* Rabh.
,, 10. *Cymbella* (*Encyonema*) *Scotica* W. Sm.
,, 11. *Cymbella delicatula* Kütz.
,, 12. *Cymbella* (*Encyonema*) *gracilis-Cesatii.*
,, 13. *Cymbella Cesatii* Rabh.
,, 14. *Cymbella microcephala* Grun.

Plate 27.

(Magnification: Figs. 1–9, × 1200; Fig. 10, × 700.)

Fig. 1. *Navicula Monmouthiana* Grun. Type form (Cleve). Monmouth. L. 0·07, B. 0·01. Fusiform. Striae 16 (middle) to 20 (ends) in 0·01 mm., nearly parallel in middle, radiate at ends. Central pores distant. Area regularly linear or rather parallel to margins. Ends show no tendency to subrostration.

,, 2. *Navicula Monmouthiana* Grun. Monmouth, Cherryfield. L. 0·07, B. 0·01. Striae 16–20 to 0·01 mm., parallel in middle, radiate towards ends; ends not subrostrate, though showing sometimes a tendency to subrostration. Area linear-lanceolate.

,, 3. *Navicula Monmouthiana-Stodderi* (*Navicula Monmouthiana* nearly passing into *Cymbella Stodderi*). Herkimer. L. 0·05. Striae 18 to 0·01 mm., punctate and radiate. Raphe nearly straight. Pores distant. Nearly sym-

metrical. Not subrostrate. Fusiform. Terminal fissures comma-like turned in same direction. Area linear-lanceolate.

Fig. 4. *Navicula Monmouthiana-Stodderi* (intermediate between *N. Monmouthiana* and *Cymbella Stodderi*). Herkimer. L. 0·07, B. 0·01. Striae 20 in 0·01 mm., radiate, punctate. Fusiform, nearly symmetrical. Ends slightly subrostrate. Terminal fissures comma-like. Central nodule slightly eccentric.

,, 5. *Cymbella Stodderi* Cleve. Herkimer. L. 0·06. Striae 18 in 0·01 mm., punctate and radiate. Ends subrostrate. Terminal fissures turned in same direction, comma-like. Area lanceolate, not abruptly dilated towards centre. Slightly asymmetrical.

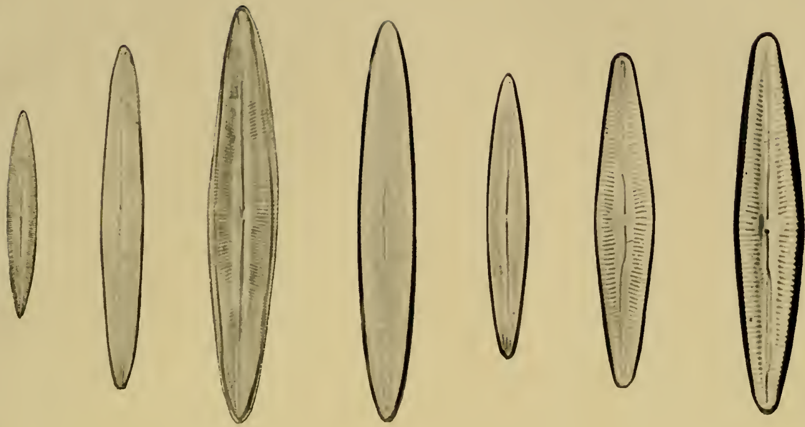
,, 6. *Cymbella Stodderi* Cleve. Herkimer. L. 0·072, B. 0·01. Striae 15 in 0·01 mm., radiate, punctate. Fusiform, slightly asymmetrical. Ends subrostrate. Axial area rather broad, lanceolate, not abruptly dilated toward centre. Very near to *N. Monmouthiana*.

,, 7. *Cymbella aequalis* W. Sm. (*subaequalis* Grun.). St. Fiore. L. 0·04. Striae 10 in middle, 14 at ends, radiate, decipient, puncta indistinct. Lanceolate, subrostrate. Area just distinct.

,, 8. *Cymbella subaequalis* Grun. (*aequalis* W. Sm.). Premnay Peat. L. 0·04. Striae 12–14 in 0·01 mm., radiate, obscurely punctate, decipient. Ends obtuse or truncate, subrostrate. Raphe almost straight surrounded by hyaline zone rather broad, dilated round central nodule.

,, 9. *Cymbella angustata* W. Sm. Herkimer. L. 0·04. Striae 16 in 0·01 mm., radiate, very faint. Ends rostrate-capitate. Margins triundulate. Axial area narrow but distinct.

,, 10. *Cymbella* (*Encyonema*) *gracilis* Rabh. Monmouth, Cherryfield. L. 0·06, B. 0·01. Striae 13 in 0·01 mm., radiate, moniliform. Margins slightly triundulate. Axial area linear, central area absent. Raphe slightly nearer to ventral margin. Central nodule on dorsal side. Ends subrostrate. Terminal nodules slightly distant from acute ends. Striae on fossil forms robust; median stria on ventral side with indistinct stigma.



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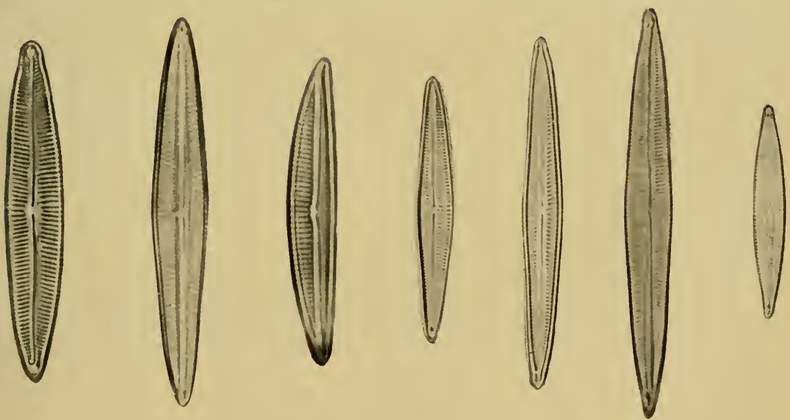


8 9 10 11 12 13 14

The "Monmouthiana Integral."

Adlard & Son & West Newman, Ltd.

Del. N. Yermoloff. Adlard & Son & West Newman Ltd. lith.

Variation in the genera Navicula-Cymbella.

Del. N. Yermoloff. Adlard & Son & West Newman Ltd. lith.

Variation in the genera Navicula–Cymbella.

PLATE 28.

(Magnification: Fig. 11, × 700; Figs. 12–19, × 1200.)

Fig. 11. *Cymbella* (*Encyonema*) *gracilis* Rabh. Monmouth. L 0·07, B. 0·009. Striae 13 in 0·01 mm., radiate, at ends parallel, moniliform. Axial area linear, no central area. Terminal fissures a slight distance from ends. Slightly triundulate. Striae robust. No stigma. Ends acute. Central nodule on dorsal side.

,, 12. *Cymbella* (*Encyonema*) *Scotica* W. Sm. Premnay Peat. Herkimer. L. 0·04, B. 0·005. Striae 13 in 0·01 mm., radiate, lineate. Terminal nodules distant from ends, turned downwards. Raphe much nearer to ventral margin. Dorsal margin arcuate, ventral margin nearly straight. Median stria on dorsal side with stigma appearing to coalesce with central nodule. Ends acute turned to ventral side. Hyaline zone distinct, elongated round central nodule.

,, 13. *Cymbella delicatula* Kütz. Herkimer. L. 0·04, B. 0·005. Striae radiate, very delicate. Median stria on dorsal side with distinct stigma. Ends acute. Terminal nodules near ends. Ventral margin slightly arcuate, dorsal margin arcuate. Hyaline zone very narrow, not dilated. Central nodule on dorsal side. Intermediate with *Encyonema Scotica* and very similar to it.

,, 14. *Cymbella* (*Encyonema*) *gracilis-Cesatii*. Herkimer. L. 0·04, B. 0·005. Rhomboidal, cymbelloid, ends acute. Terminal nodules distant. Striae 20 in 0·01 mm., radiate, punctate. Median stria on dorsal side with distinct stigma. Central nodule on dorsal side, ventral margin slightly gibbous, dorsal margin convex. Areas indistinct. Terminal fissures comma-like, bent towards ventral side. Sometimes still narrower and longer.

,, 15. *Cymbella* (*Encyonema*) *gracilis-Cesatii*. Herkimer. L. 0·045, B. 0·0045. Striae 18 in 0·01 mm., radiate, punctate. Rhomboidal, ends acute, terminal nodules distant from ends. Central nodule on ventral side. Ventral margin slightly triundulate, dorsal margin

convex. Median stria on ventral side with stigma. Areas narrow but distinct.

Fig. 16. *Cymbella* (*Encyonema*) *gracilis-Cesatii.* Herkimer. L. 0·05, B. 0·006. Striae 18 in 0·01 mm., radiate, punctate. Ends acute. Median stria on ventral side has a punctum, so that the stria appears to coalesce with nodule. Ventral margin slightly triundulate, dorsal margin convex. Areas distinct. Terminal nodules distant from ends. Sometimes more rhomboidal and more cymbelloid. Resembles *Encyonema gracilis.*

,, 17. *Cymbella* (*Encyonema*) *Cesatii* Rabh. Premnay Peat. L. 0·06, B. 0·006. Striae 19 in 0·01 mm., faint, radiate, no punctum on medium stria. No axial area ; central area small and rounded. Very slender, symmetrical, slightly triundulate, especially one of the margins. Terminal nodules distant from ends.

,, 18. *Cymbella microcephala* Grun. St. Fiore. L. 0·025, B. 0·004. Striae about 25 in 0·01 mm., very faint, nearly parallel. Ends rostrate-capitate. Areas indistinct. Asymmetrical.

,, 19. *Cymbella microcephala* Grun. Premnay Peat. L. 0·03. Striae 25 in 0·01 mm., faint, punctate, nearly parallel. Asymmetrical, ends rostrate-capitate. Areas distinct.

A FURTHER CONTRIBUTION TO OUR KNOWLEDGE OF THE TWO AFRICAN SPECIES OF *VOLVOX*.

By G. S. West, M.A., D.Sc., F.L.S.,
Mason Professor of Botany in the University of Birmingham.

(*Read April 9th*, 1918.)

Plates 29 and 30.

Some few years ago the author published a paper * on "Some New African Species of Volvox," described at that time exclusively from vegetative individuals. One of these, *Volvox Rousseletii*, is the largest known species of the genus and was obtained by Mr. Rousselet from a pool near Gwaai in Rhodesia in September, 1905; the other species, *V. africanus*, was collected by Mr. R. T. Leiper in Uganda in July 1907.

Since then Mr. Rousselet has obtained some plankton-material collected by Dr. Jakubski of Lemberg (Lwòw) from small temporary pools in the Ussangu Desert in the African region formerly known as "German East Africa," and in this material were present sexual colonies of the above-mentioned African species of *Volvox*.

Although the vegetative characters were amply sufficient to establish these two species, great interest is naturally attached to the discovery of their sexual colonies, since it assists in completing the description of these African types of *Volvox* and shows still more clearly that they are distinct races as compared with the European types.

Mr. Rousselet has published a preliminary note † stating how he obtained these sexual colonies in 1914 and that they had been submitted to me for detailed investigation.

The sexual colonies have been photographed and a selection of these photographs appear on the accompanying plates. Unfortunately, no male colonies of *V. africanus* were found in this East

* G. S. West in *Journ. Quek. Micr. Club*, ser. 2, vol. xi., Nov. 1910, pp. 99–104.

† C. F. Rousselet in *Journ. Quek. Micr. Club*, ser. 2, vol. xii., Nov. 1914, pp. 393–394.

African material, although from a previous observation on material from Uganda it seems probable that the male colony is similar to that of *V. aureus*.* On the other hand, both male and female colonies of *V. Rousseletii* were abundant. The outstanding feature in both species is the relatively large number of ripe oospores in the female colonies. In *V. Rousseletii* not only were there purely male colonies (figs. 1 and 7), but also male colonies which, in addition to numerous antheridia, possessed daughter-colonies which had arisen from parthenogonidia (fig. 2).

There is a marked polarity in all the sexual colonies. The vegetative colonies of *V. Rousseletii* are approximately spherical, but both male and female colonies are egg-shaped with a general concentration of the sexual elements towards the narrower pole (consult all the figures of colonies).

The following tabulated statements indicate the differences between the two African species:

Volvox Rousseletii. G. S. West.	**Volvox africanus.** G. S. West.
Vegetative colonies subglobose; diameter, 1,125–1,240 μ.	Vegetative colonies ovoid-ellipsoid; length, 345–610 μ; breadth, 295–480 μ.
Number of cells, 25,000–50,000.	Number of cells, 3,000–8,000.
Cells small, very densely aggregated, 4–6·5 μ in diameter, somewhat angular with relatively broad connecting strands of protoplasm.	Cells less densely aggregated, 8–9·5 μ in diameter, almost globose with long delicate connecting strands of protoplasm.
Daughter-colonies, regularly 8.	Daughter-colonies, 1–4.
Oospores, 120–150 (average 128), densely clothed with strong conical spines; average diameter without spines, 44 μ; length of spines, 11–12 μ.	Oospores, 70–80 (average 74), with a thick smooth wall; average diameter, 45 μ.
Androgonidia (and subsequently antheridia) very numerous in each male colony (usually several hundred).	Androgonidia not yet observed with certainty (but probably very numerous).
Antherozoids and oospheres produced in different colonies.	Antherozoids and oospheres produced in different colonies? [This is probable, since only female colonies have so far been definitely observed.]

* G. S. West, *l.c.* p. 103.

The characters set out in the above table clearly show that *V. Rousseletii* and *V. africanus* are two species differing very much from each other both in their vegetative colonies and in their oospores. It is interesting, however, to compare these African species of *Volvox* with the two well-known European species.

V. Rousseletii is without doubt the African species comparable with *V. globator* of Europe. It differs from the latter vegetatively in its larger colonies and in the much greater number of their constituent cells, which are far more closely aggregated. The sexual differences are equally well marked. The antheridia are much more numerous and apparently are not developed in the same colonies as the egg-cells. In the female colonies the ripe oospores are about four times as numerous as in *V. globator* and they show a decided concentration towards one pole of the colony (fig. 8). Moreover, the wall of each oospore is furnished with long conical *spines* (consult fig. 3), very different in appearance from the depressed conical *warts* on the oospores of *V. globator*.

V. africanus affords a comparison with *V. aureus* not unlike that between *V. Rousseletii* and *V. globator*. It differs vegetatively from *V. aureus* in the ovoid-ellipsoid shape of its colonies, in the larger number of constituent cells, and in the nature of the daughter-colonies. The latter vary from 1 to 4 (commonly 3) in number, are of large size and ovoid form, and become flattened by compression, whereas in *V. aureus* there are from 4 to 14 daughter-colonies of approximately spherical shape. It seems probable that the male colonies of *V. africanus* are similar to those of *V. aureus*, but the female colonies differ in the presence of a much larger number of ripe oospores, averaging 74 in *V. africanus* as against 6 in *V. aureus*. In both these species the walls of the ripe oospores are thick and smooth.

Explanation of Plates 29 and 30.

Figs. 1–3. *Volvox Rousseletii*. 1, male colony showing the ovoid form and the large number of antheridia concentrated towards the narrower end, × 50. 2, male colony with antheridia and young daughter-colonies, × 50. 3, outline of spiny oospore, × 500.

Figs. 4–6. *Volvox africanus.* 4 and 5, female colonies with ripe oospores, × 74. 6, outline of ripe oospore, × 500.

Figs. 7 and 8. *Volvox Rousseletii.* 7, male colony showing marked polarity in respect of the antheridia, × 50. 8, female colony with large number of ripe oospores and also showing polarity, × 50.

THE BINOCULAR MICROSCOPE.

By Edward M. Nelson, F.R.M.S.

(*Read October 8th,* 1918.)

Among microscopists there are some who regard the binocular merely as a toy or plaything, while others take it more seriously and consider it an instrument useful in scientific research. The bulk of microscopes in use are, however, monoculars. This no doubt is partly due to the less cost and greater portability of the monocular instrument, and partly to the failure of the Wenham and Stephenson binoculars with high-power objectives, which of course means that if high-power work had to be done, one could not get on with a binocular alone, a monocular would have to be added to the outfit; the purchase of two microscopes instead of only a monocular would necessarily deter many from even thinking of buying such " a useless plaything as a binocular."

A pertinent question has been asked, " What discoveries have been made with a binocular?" It must be admitted that so far it is difficult to point to any. Before this note is finished we trust that a satisfactory answer will, for the first time, have been found to that question, first asked by Hooke 250 years ago. To proceed to our investigations, let us take the Greenough as our standard instrument. It consists, as you are all aware, of two erecting microscopes inclined to one another at the normal inclination of the eyes at 10 inches, viz. $14\frac{1}{2}°$. This yields the perfect ortho-stereoscopic image. Hitherto there has been no standard to which a stereoscopic image could be compared to determine if the relief in the image was too high or too low. In this instrument the full apertures of both objectives are clear, and the illumination in the tubes is the same. The Wenham is so well known that a description is unnecessary.

A third binocular is the new Parallel tube;* it, like the Wenham, uses a single objective. Three kinds of vision can be obtained with this instrument, viz. non-, pseudo-, or ortho-stereoscopic, which is effected by adjusting the separation between the tubes either equal to, greater, or less than that of the interpupillary distance of the observer's eyes. In this microscope, which some of you may have seen, the illumination in each tube is nearly the same. When the tube separation is equal to that of the interpupillary distance, the whole of the pencils emerging from the eye-pieces pass uninterruptedly through the pupils of the eyes, the image therefore has its maximum brightness, and is non-stereoscopic. But when the tubes are closed to about 1 mm. less than the interpupillary distance, the inner portion of the emergent pencils are cut out by the iris of the eyes, the image becomes ortho-stereoscopic and loses brightness.

This reduction in the brilliancy of the image is a guide in setting the tubes to their proper separation for ortho-stereoscopic images. If we examine the same low-power object with a Greenough and a Wenham, arranging matters so that the measured magnifying powers are identical, we shall find the stereoscopic relief in the image given by the Wenham is a good deal below that of our standard; as the powers increase, this deficiency becomes less. The falling off in the relief of the image in a Wenham with powers ranging from 1 inch downwards is an important point scarcely noticed by microscopists; on the contrary, the Wenham together with the Stephenson are regarded by them as instruments yielding perfect ortho-stereoscopic images. Now, if attention be directed to the apparent size of the images, that in the Wenham will be noticeably larger than that in the Greenough, although the measured powers are identical. The Parallel tube binocular was now set up, and the powers increased to Greenough 46, Wenham, 44, Parallel tube, 42. The amount of relief in the Greenough and Parallel tube was the same, and in each of them it was greater than in the Wenham, but the apparent magnification was much greater in the Parallel tube, next in the Wenham, and least of all in the Greenough.

* Felix Jentzsch, Ph.D., "The Binocular Microscope," *Journ. R.M.S.*, 1914, pp. 1–16.

Similar results were obtained when the powers were further increased to 76, 73, and 71 diameters respectively, with the exception that with the Wenham there was less falling off in the relief. It is remarkable that the observed difference in the stereoscopic relief depends to some extent upon the objects on the stage. For example, if the objects are the inside and outside views of *Triceratium fimbriatum* there will be no very great difference in the stereoscopic relief in these three instruments, but let this object be exchanged for some polycistines, a considerable difference in the strength of the stereoscopic effects will at once be apparent. It is therefore most important that anyone, when comparing the stereoscopic relief in different kinds of binoculars, should take care to have a suitable object upon the stage.

There is another interesting point worth notice, viz. if an object under a Greenough be examined with only one eye, and a mental estimate of its size be made, then the eye removed from the instrument and distant objects about the room looked at for a few seconds, afterwards the object under the microscope again examined, but this time with both eyes, the image will appear smaller than when seen by only one eye. With the Wenham there is not this difference, but with the Parallel tube instrument the difference is the other way, the image seen with both eyes being larger than that seen with one eye. It is necessary to focus the eyes upon things in the room before each separate experiment is made.

As to the ease and comfort of vision, to my eyes the Greenough and Wenham are similar, while that in the Parallel tube is not quite so comfortable, when it is arranged for ortho-stereoscopic images, because of the necessity of keeping the head perfectly steady, so that the emergent pencils may be equally cut by each eye. This discomfort increases with the higher powers, as the emergent pencils get smaller. This certainly is the defect in all those kinds of instruments where the stereoscopic relief depends upon the cutting of the emergent pencils by the iris of the eyes. It is not a very serious one ; if caps with stops cutting out about one-quarter of the aperture with low eye-pieces, and about one-third with high ones, are placed over the eye-pieces, vision is thought to be easier. This plan of using caps with stops over

the eye-pieces for producing stereoscopic vision is due to Wenham. There are those who are unable to combine the images, even in a Greenough, but who have no difficulty in doing so in a Parallel tube binocular; while the experience of others is just the reverse. It is probable that less than half those who use microscopes are able to see a stereoscopic image in a microscope, or in any other optical instrument. With regard to the sharpness of the images, those in the Greenough and Parallel tube were very similar, and both were sharper than those in the Wenham. The difference in the apparent sizes of the images in those three binoculars is due to the fact that the apparent distances of the projected pictures are different. With the Parallel tube binocular the eye sees the virtual images projected to a greater distance than with the convergent tubes of the Greenough. It has been stated that there is no definite measurable distance for the plane of the virtual image, but obviously these experiments prove that with a binocular it is not so.

As 76 is the highest power with my Greenough, the following experiments will be confined to the other two binoculars. The object used in the previous experiments was a common circular, and not quite spherical, polycistine, mounted opaque, and illuminated by a side reflector; but as we are now about to deal with higher powers, a more suitable object must be used. A good one is a diatom, formerly called *Actinosphenia splendens*, but now known as Actinoptycus. Strictly speaking, it is an Aulacodiscus, it has ten convex rays, down the centre of each runs a true "aulax," ending in a small process. When this is examined with, say, a 1-inch objective on a dark ground with a condenser of low angle, or a spot lens, the aulax is seen as a bright white line, but with a condenser of larger angle it becomes a black line. The reason for this is not understood.

This aulax is, by the way, an excellent test when viewed upon a dark ground for medium objectives, say 2/3 and 1/2. When this diatom was placed under the Wenham, power 270 and dark ground, the aulax when in a horizontal position was sharply defined, but when in a vertical one it was poorly imaged. In the Parallel tube instrument, under the same power, the aulax was sharply defined in all directions. This test is a good one

because it deals with the coarse features of a fairly large diatom and not with periodic structures, such as striae, secondary markings, etc. As a test with striae a moderately fine *Navicula lyra* may be used. The Parallel tube instrument will resolve the transverse striae when the valve is in any direction, while the Wenham will only do so when the valve is vertical, or nearly so. The stereoscopic relief in these experiments was stronger in the Parallel tube binocular.

Let us now examine a *Coscinodiscus radiatus*, which is an exceptionally flat diatom. The Parallel tube binocular revealed a feature never before observed, viz. that the "Omphalos" is at the bottom of a small pit. Some other diatoms were then examined with reference to this detail, and some other Coscinodisci were found to have similar pits, an *Arachnoidiscus ornatus* from Japan had one also. The diatom was then examined under a similar power (270) in the Wenham. Knowing that this little pit existed, its presence could be recognised, but it is doubtful if it would have been discovered if its presence had not been known. The fact that it has never been previously seen proves that this is so.

The Parallel tube binocular has revealed another feature of this diatom, viz. that its floor is anything but flat; parts are raised and parts depressed, this quite irregularly and not in any symmetrical pattern. By way of illustration, suppose some pastry dough had been spread smoothly on a table, and that some children had come when the cook was not looking and had pressed in portions of the dough with their fingers and hands. If a layer of empty honeycomb cells could have been treated in the same way as the soft dough, we should have a fair representation of the surface of this diatom, which hitherto has been thought to be flat. The spread slide, which contains this diatom, was bought in the year 1868; it has been kept fifty years in a special box of test objects, and not in the diatom cabinet. It is quite impossible to say how many hundreds of objectives have been tested on it, but probably there is nowhere a diatom slide that has been worked over to anything like the same extent as this one. Imagine then my surprise on seeing quite a new aspect of this well-studied *C. radiatus*. It was as great as if I had found the hours on my

watch painted in Arabic figures, when I have known them as Roman for the greater part of my life.

It has been found that upon the outside of this diatom the larger areolations belong to the depressed portions, and the smaller ones to the raised; of course when an inside view is obtained the reverse is seen. These features have neither been seen, nor could have been found, with a monocular, but when known they can be detected with a Wenham, but it is very doubtful if ever they would have been discovered with that instrument. It is a very different thing to discover an object whose presence is unknown, and to find it when one both knows that it is there and knows what to look for.

This then is the answer to the question, "What detail has been discovered with a binocular that has not been seen with a monocular?" It is perfectly certain that this structure would never have been discovered with a monocular.

Perhaps someone will ask, "What light does the new binocular throw upon the interpretation of the Podura scale?" The Podura scale has undergone a more searching microscopical examination than any other object, and yet it remains the microscopist's enigma. In a paper on this subject * the various views of several observers were given, besides that of my own, which was that the exclamation mark was a cuniform-shaped elevation and not a plumelet. It has now been examined with an apo. 1/12 of 1·4 N.A. and No. 18 compensation eyepieces on the Parallel tube binocular. From an examination of this kind one would have expected an immediate and decisive answer, but this was not to be had, for the object is a very thin one, and such objects, as has been already pointed out, do not yield much stereoscopic relief. Of course nothing could be easier with either a monocular or binocular, by means of a small cone, to make a strong image of a raised exclamation mark, but would it be a true image? The evidence supplied by the Parallel tube binocular is that they are depressions. Suppose there is a surface of cheese with grooves or furrows, more or less parallel, on it, then if with a cheese-taster some scoops be made in these furrows, with a small and slightly deeper depression at the end, we shall have a rough representation of this object as

* *R. M. S. Journ.*, 1907, p. 393, pl. 16.

seen in a Parallel tube binocular. Drawings and photomicrographs of many microscopical objects are of little value, the things that are wanted are models of the structures. We want models of diatoms and models of insect scales. I put forward no definite opinion upon the structure of the Podura scale, and still keep an open mind regarding it; all that can be said is that this depression image is a fair description of the appearance of the exclamation marks as viewed critically under a Parallel tube binocular. The exclamation mark is an enigma still, and no one has any pretext for saying, "I know all about the Podura scale, for I have examined it under a high-power binocular."

Those who have read my former paper on binoculars * will notice that my views have undergone modification. At the time of writing it the Parallel tube binocular had been only three months in use, but now it has been fairly constantly employed for four years. Previously, in company with many other microscopists, I was obsessed with the idea of the perfection of the Wenham binocular images, and had not adopted at that time the Greenough image as a standard for stereoscopism. It will be seen, from what has now been written, that the superiority of the images in the Parallel tube binocular is recognised both as regards their sharpness and stereoscopic relief.

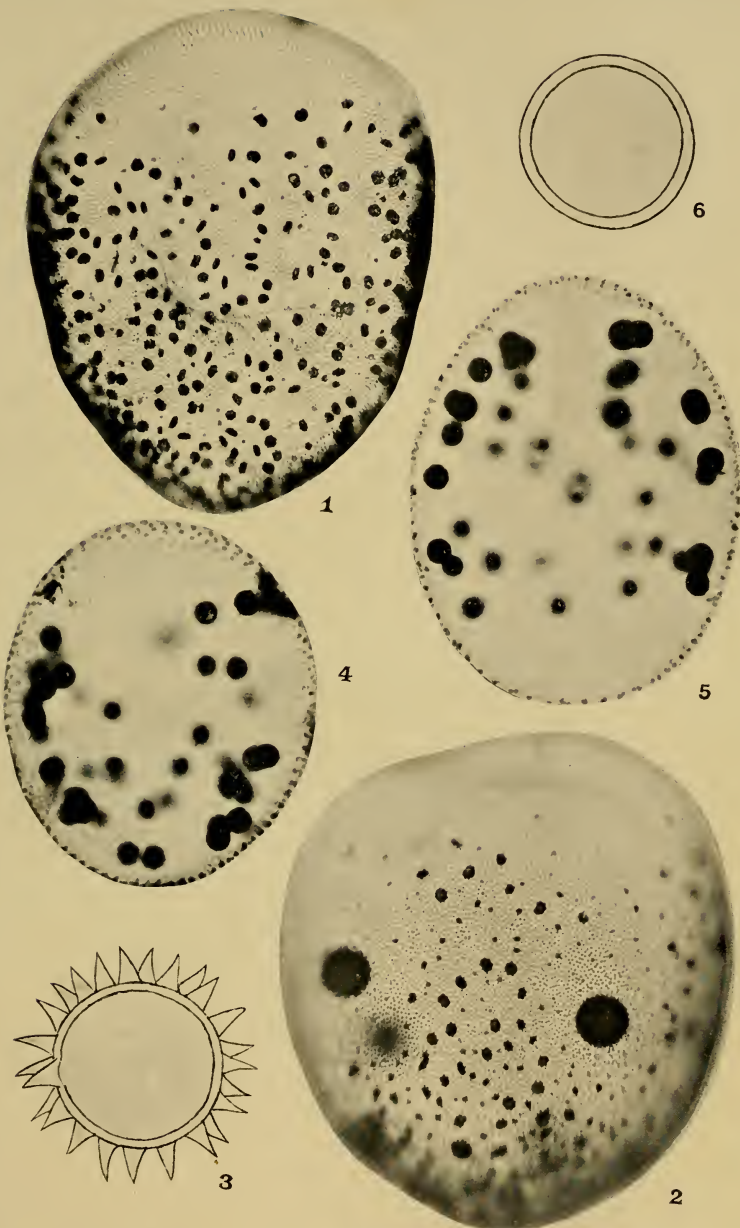
In conclusion, one improvement for the Parallel tube binocular may be suggested, which may with advantage be adopted when that instrument is made, let us hope, in this country. At present the tube separation adjustment is effected by rack and pinion, which is far too quick; a movement by a right- and left-handed screw would be more delicate and far preferable. I regret that, owing to my not possessing a Stephenson's binocular, experiments with that instrument have not been included, but there is no reason to doubt that the results would have been precisely similar to those obtained with the Wenham.

New Points of Microscopical Interest Brought Forward

1. The adoption of the Greenough as a standard for stereoscopic relief.

* *Q. M. C. Journ.*, 1914, vol. xii., No. 95, p. 378.

2. Different kinds of binoculars, with identically the same measured magnifying powers, yield different apparent magnified images.
3. While some objects show little, if any, difference in stereoscopic relief with different kinds of binoculars, other objects show much difference.
4. Different kinds of binoculars show different apparent magnifying powers when one eye or two eyes are used.
5. The "aulax" in an *Actinosphenia splendens* is white on a dark ground if the angle of the substage condenser is low, but black if the angle is wide.
6. A pit and unevenness in the floor of *Coscinodiscus radiatus* is discovered with a Parallel tube binocular.
7. Fine adjustment for setting the interpupillary distance of tubes in Parallel tube binoculars.



Photomicrogr. G. S. West.

Figs. 1–3, *V. Rousseletii*; Figs. 4–6, *V. africanus*.

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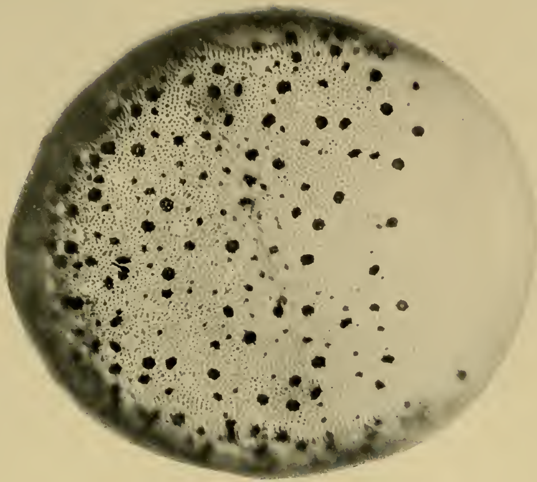

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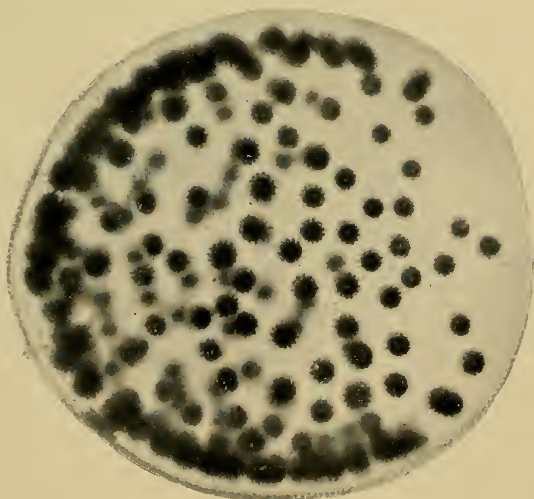

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Photomicrogr. G. S. West.

Figs. 7 and 8, *V. Rousseletii.*

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NOTES.

MICROSCOPE EYE-PIECES.

——	LONG TUBE.				
Number	A × 5	B × 7½	C × 10	D × 20	E × 30
Focus	50·8	33·8	25·4	12·7	8·46
r	∞	∞	∞	+ 16·7	+ 11·2
s	− 15·4	− 10·6	− 8·1	− 5·6	− 3·7
Diameter	19·0	14·0	11·0	6·0	4·0
Hole in diaphragm	24·0	19·0	15·0	5·0	3·0
R	∞	∞	∞	+ 67·0	+ 54·0
S	− 39·0	− 29·0	− 23·0	− 16·0	− 10·9
Diameter	32·0	28·0	23·0	10·0	8·0
Distance between surfaces	57·7	39·4	29·2	15·3	10·9
Field lens down from top of tube	54·6	48·3	21·6	7·0	2·4

——	SHORT TUBE.				
Number	× 5	× 7½	× 10	× 20	× 30
Focus	37·6	25·06	18·8	9·4	6·26
r	∞	∞	+ 24·0	+ 12·1	+ 8·1
s	− 11·3	− 7·8	− 8·0	− 4·1	− 2·7
Diameter	12·0	10·0	9·0	4·0	3·0
Hole in diaphragm	13·0	10·0	7·0	4·0	2·5
R	∞	∞	+ 66·0	+ 51·0	+ 41·0
S	− 29·0	− 21·7	− 23·5	− 12·3	− 8·7
Diameter	20·0	20·0	16·0	8·0	6·0
Distance between surfaces	43·4	29·3	23·0	12·3	8·4
Field lens down from top of tube	37·3	21·3	14·8	3·9	0·5

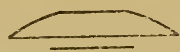
Measurements are in mm.
Glass: Eye Lens, Chance hard crown, n = 1·5175 ν = 60·5.
Field Lens, Chance extra light flint, n = 1·5333 ν = 48·5.

EDWARD M. NELSON.

OIL-IMMERSION DARK-GROUND ILLUMINATOR.

N.A. 1·45, Equivalent Focus 6·9 mm.

This dark-ground illuminator, after Stephenson, is of a very simple construction, and in use is most efficient. Its equivalent focus is 6·9 mm., which enables it to yield a large image of the source of light. Its N.A. is full 1·45, which is greater than any dark-ground illuminator now made. Radius, 18·5 mm.; this



(Figure full size.)

surface to be silvered. Flat top, 8·06 mm. in diameter. Diameter at bottom, 21·5 mm. Thickness, 3·0 mm. Thickness of complete plano-convex lens before top is cut off, 3·44 mm. Diameter of stop, 11·5 mm. It is most important that the thickness should be worked exactly true to the formula.

Glass: Chance dense flint, $n = 1{\cdot}6225 \quad \nu = 36{\cdot}0$.

Edward M. Nelson.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the 533rd Ordinary Meeting of the Club, held on April 9th, 1918, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on March 12th were read and confirmed.

Messrs. Wm. Moore Tipping, A. Harry Matthews Fox and Ernest J. Vickery were balloted for and duly elected members of the Club; nomination forms were read on behalf of two for the first time.

The Secretary announced that the first excursion of the Club would be to the Royal Botanic Gardens, Regent's Park, on Saturday, April 13th, that there would be a Gossip Meeting on the 23rd inst., and that at the next Ordinary Meeting on May 14th Mr. F. Martin Duncan would give an address on "Insects as Transmitting Agents of Disease," illustrated by lantern slides and prepared specimens.

The President then called upon Sir Nicholas Yermoloff, K.C.B., to read his paper on "Some Intermediate Forms of the Genera Navicula and Cymbella."

Sir Nicholas said:—All students of Diatomology are invariably impressed by the immense number of forms, species, subspecies and varieties described, named and classified. The differences which have led to the creation of new forms are sometimes very trifling and uncertain, based upon personal impressions of observers, and consequently a maze of confused synonymy has arisen. From time to time various distinguished authors have tried to remedy this state of things, striving to reduce the existing number of admitted species and varieties. Such regroupings have been attempted by Cleve as regards the genus Navicula, by Cox and Rattray as regards Coscinodiscus. One such writer

has said: "The reduction of the enormous catalogue of species of Diatomaceae is a consummation devoutly to be wished." I am not so sure that it is to be so devoutly wished as that. It seems to me that the careful labour of registering minutiae and the consequent subdividing of Diatom systematics has been both fruitful and inevitable. What we should rather wish for is not a curtailing of the differentiating operations, but a process of synthetic integration, undertaken, and only possible, after the study of variations has been thoroughly carried out. The variations of intermdiate forms of Diatoms are by no means abrupt; they pass insensibly from one form into another. An attempt at synthetic integration forms the subject of this paper.

An American fossil freshwater Diatom—*Navicula Monmouthiana*—may be considered as an ancestral form of a whole series of Cymbella species. This ancestral form seems to have passed, through the course of many centuries, through a long series of slight transformations, evolving several forms of Cymbellae extremely similar to each other, and closing the series at a very small form called *Cymbella microcephala.*

Sir Nicholas then pointed out by means of lantern slides the gradual evolution through various intermediate forms of *Cymbella microcephala* from *N. Monmouthiana*, describing in detail the various points of similarity and difference between one member of the series and the next. A series of nineteen drawings of the various species and varieties dealt with was also shown.

After remarks had been made by the President and Messrs. H. Morland, N. E. Brown, D. Bryce, and Dr. Leeson, a hearty vote of thanks was accorded to Sir Nicholas Yermoloff for his interesting paper.

The President then called upon the Secretary to read Prof. G. S. West's paper, "A Further Contribution to our Knowledge of the Two African Species of Volvox." In 1910 the author described, from vegetative individuals only, two species of African Volvox, *V. Rousseletii* and *V. Africanus.* Since that time their sexual colonies have been discovered. Unfortunately, no male colonies of *V. Africanus* were present in the new material, but both male and female colonies of *V. Rousseletii* were abundant. Prof. West gives a table showing the characters of the two species and then makes an interesting comparison between them and the two well-known European species, *V. globator* and *V. aureus.*

Mr. Scourfield drew attention to this comparison, and stated that the European species were also to be found in Australia.

The President then proposed a vote of thanks to Prof. West for his valuable and interesting contribution.

At the 534th Ordinary Meeting of the Club, held on May 14th, 1918, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in the chair, the minutes of the meeting held on April 9th were read and confirmed.

Messrs. Geo. Thomas Hollis and Edgar W. F. Browning were balloted for and duly elected members of the Club; six proposal forms were read for the first time.

Dr. Rendle said there had been some discussion about the method of informing members of the subjects of forthcoming papers; he said that it was not always possible to announce these beforehand, but that when they were known in time they were announced in the *English Mechanic*, and notices were also displayed in the windows of some of the principal opticians.

The Secretary announced that the next Ordinary Meeting would be on June 11th, and that there would be a Gossip Meeting on May 28th, and an excursion to Hanwell and Greenford on May 25th.

The President then called upon Mr. F. Martin Duncan to deliver his address on "Insects as Transmitting Agents in Disease."

Mr. Martin Duncan said that this branch of entomology was a comparatively recent study. He dealt very briefly with the housefly as a disease-carrier, and stated that the blowfly, although occasionally a carrier, is not so dangerous. The flesh fly, easily distinguished by its striking markings, has been causing trouble on the Western Front by laying its eggs in wounds. This fly is very persistent in attacking meat, and will drop its larvae through the gauze covers which are sometimes used as a protection. The biting flies are more important. Anthrax has been communicated to man through the bite of a tabanid fly whose mouth-parts were contaminated by its having bitten an infected animal. In Africa, *Trypanosoma gambiense* (the protozoon which causes sleeping sickness) is carried from infected persons to others by the biting tsetse flies, *Glossina palpalis* and *G. morsitans*. These flies frequent

shady places close to fords, or drinking or washing places, and after biting return to their resting-places until another opportunity occurs. Some trypanosomes, which do not appear to harm their usual hosts, when transferred to other animals cause disease, and possibly death. The tsetse flies are larviparous, the larvae being nourished in the body of the female, and pupating soon after they are discharged. The disease called Ngana, which affects horses and cattle, is transmitted by *G. longipennis.* The opening up of the African trade routes is largely responsible for the spreading of sleeping sickness. The early settlers often lost most of their oxen in passing through " fly-belts," and " salted " animals—*i.e.* those which had had the disease mildly, and were consequently immune—were much sought after. They used to wait for dull weather or dark nights, when the flies were not so active, to pass through the infested districts.

The speaker then dealt with mosquitoes, and described the ravages of yellow fever and malaria in South America and Panama. The French failure to cut the Panama Canal was owing to these diseases, and it was due to the researches of Manson, Ross, Bruce, Grassi and others that the responsibility of communicating these diseases has been traced to mosquitoes. Means having been adopted to destroy these insects, not only has it been possible to cut the Panama Canal without serious loss of life, but Santos and Rio, where formerly yellow fever was rampant, have practically become health resorts. Mr. Martin Duncan recounted some of his experiences in " oiling " the ponds in these districts—*i.e.* covering the surface of the water with a film of mineral oil that the air-breathing larvae are unable to penetrate with their breathing siphons, and are consequently drowned. Malaria or ague used to be common in the English fen districts, but now most of the swamps have been drained: and, the mosquitoes' breeding places having been destroyed, the disease has almost died out. Some strange " cures " for ague were described, and a short account given of the life-history of the anopheline mosquitoes and the malaria blood-parasite.

The human flea may transmit Kala Azar, and rat-fleas are the carriers of plague. There are two ways by which inoculation may possibly be effected. Faecal matter containing plague bacilli is frequently discharged while the flea is sucking blood, and this infected material may be rubbed into the wound by the

irritated victim. Sometimes the alimentary canal of the flea becomes completely blocked by a mass of *Bacillus pestis*, and then, when the flea tries to suck, a churning action takes place, and some of the bacilli are regurgitated, and pass into the wound.

Typhus fever and "trench fever" are diseases that are transmitted by lice. It was typhus from which the Serbian Army suffered so severely. These diseases are probably transmitted by inoculation from the excreta. The bed-bug is a possible carrier of typhus, and an Indian bed-bug is responsible for spreading the disease known as Oriental sore.

The so-called harvest-mite, by burrowing under the skin, causes, in some cases, such intense irritation that a certain amount of fever results. Ticks convey various diseases of both man and animals from infected to healthy subjects. When a tick is full-fed it falls to the ground from the animal on which it has been feeding, and rests until it requires another meal, when it climbs on to another animal and feeds again. If the first animal should be diseased the second may possibly become infected.

The President emphasised the importance of studying the habits of a disease-carrying insect before fighting it.

The Secretary read the following note from Colonel Clibborn, who was unavoidably absent from the meeting:

That immunity to the results of malarial infection may be acquired naturally appears to be demonstrated in the case of the Tarus—inhabitants of the Tarai tract in North-West India.

The Tarai is a belt of clay soil deposited as the result of the denudation of the mountain slopes. It has a high spring level, is covered in large part by forests, stretches of high grass and swamps. It is flooded in many places during the wet season, and, as may be imagined, has an abundant and varied supply of animal, plant and insect life. It is the paradise of the sportsman and a fruitful field for the naturalist, who can, however, only visit it with a due regard to health during the cold weather, or for short periods in the early part of the hot season. The climate is considered *deadly* in the latter part of the rains and while the flooded areas are drying up.

The Tarus are indigenous inhabitants of the Tarai—live in their villages there all the year round, and do not suffer to any marked extent from ill effects due to the climate. They are great sportsmen—eat fish, meat whenever they can get it,

particularly wild pig—and indulge frequently in native liquor. They assert this is necessary as a protection from the effects of the climate. They cultivate the land close to their villages, and, on the whole, pass happy, contented lives. The Taru children appear to enjoy as good health as their parents.

The soil of the Tarai is productive and rent inconsiderable; there are, therefore, many inducements to cultivators from the densely populated tracts at a distance from the hills to emigrate to the Tarai and occupy portions of the untenanted lands. This goes on intermittently, and, as well as I can remember, the loss of life is between 70 to 80 per cent. In any case it is very large indeed. The Government officials who administrate the Tarai cannot reside there throughout the year without certain loss of health, if not worse. Even during the cold weather it is necessary to take quinine and live carefully. It has been found that very minute daily doses of quinine taken for some weeks before entering the malarious tracts, and continued throughout the stay there, is practically a complete protection against the results of infection. In one instance, out of a party of about one hundred persons—European and native—who passed some six months in the Tarai, only one man was affected, and this was the one man of the party who had not been given the preliminary treatment.

These latter points are somewhat wide of the question of naturally acquired immunity, but may be interesting with reference to malarial infection generally.

Mr. C. D. Soar stated that the "harvest-mites" were the larvae of a so far undetermined species, probably a *Trombidium*, and that it was quite possible that they belonged to more than one species.

In reply to a question by the President concerning the occurrence of large numbers of fleas in deserted houses, where they could not obtain their natural food, Mr. Martin Duncan said that fleas that had never tasted blood seemed to be able to live a much longer time than those which had.

A hearty vote of thanks was accorded to Mr. Martin Duncan for his address.

At the 535th Ordinary Meeting of the Club, held on June 11th, 1918, the President, Dr. A. B. Rendle, M.A., F.R.S., F.L.S., in

the chair, the minutes of the meeting held on May 14th were read and confirmed.

Messrs. Ashley E. Oram, John A. Manning, Geo. Richard Titchener, H. F. Green, F. Adolphus Brokenshire, Chas. J. Lock and Wm. Geo. Collins were balloted for and duly elected members of the Club.

The Secretary read a note by Mr. E. M. Nelson on "Pond Life," dealing with the particles 0·65 to 1·4 μ in diameter present in the cells of the confervoid algae which are old and about to decay. If these particles, which are in Brownian movement, are examined with crossed Nicols, those in the smaller filaments become brilliant, while those in the larger filaments, which are smaller, remain dark. This also can be seen with a 1/6 in. If a water imm. 1/12 in. be used the particles are seen to have the power of becoming invisible and again reappearing; they also grow, becoming double, like a diplococcus, and then passing on to the tetraspore stage, but they have not been seen to divide into separate spores. Mr. Nelson suggests that the movement is a combination of pedesis and flagellate movement.

The President then gave an address on "Some Points in the Structure and Growth of Grasses." Dr. Rendle said grasses, as generally understood, are herbs with slender stems and narrow, ribbon-like leaves. They form one of the largest and most wide-spread families of flowering plants, adapted to very different conditions of soil and climate, but with a remarkably uniform plan of structure. In the aggregation of many individuals of one or a few species, either growing alone or scattered through a mixed herbage, covering large areas, the family forms a pre-eminent type of the earth's vegetation, as *e.g.* in meadows and pastures, steppes and prairies. These sociable grasses keep the soil warm and moist, and protect other plants during cold or dry seasons, and their roots and creeping stems help to break up the soil. Dr. Rendle then showed on the screen photographs of various types of grass vegetation, viz. calcareous limestone and chalk downs, with a short pasture largely composed of sheep's fescue, probably of great age, and likely to continue treeless on account of the thin layer of soil and poor supply of underground water; swamps, in which the broad-leaved reed flourishes; mud flats at Southampton Water, Poole Harbour, and other places, where thousands of acres have been taken over by *Spartina*

Townsendi, whose long spreading roots and stolons bind the soil together, while the thick stems and leaves collect flotsam, and so, in time, reclaim the land; sand dunes, on which marram grass grows, and by sending out its long roots and runners may so consolidate the sand that other plants are able to grow there. This grass, even if it becomes covered up by the drifting sand, will grow right up through it. *Agropyron junceum*, though not so common, will stand the sea spray even better. The woody, tree-like bamboos are common in Asiatic jungles, and there is often a bamboo zone on the mountains of tropical Africa and the Andes.

The leaves of grasses are arranged in two alternate rows. Shoots are produced, as usually, in the axils of the leaves. Barren shoots never occur on annual grasses. The shoots may grow up within the leaf-sheath (intravaginal) or they may break through and spread laterally from the base (extravaginal). The first method of growth gives rise to isolated tussocks characteristic of a warm climate (steppes and savannahs), the second method produces turf and sods such as we find in a cool or temperate climate.

The grass stem, or "culm," grows not only at the tip, but at the bases of the internodes, where the soft, growing tissues are supported by the leaf-sheaths. The "nodes" are thickenings of the leaf-sheaths, and their function is to raise the culm to an erect position if it should become bent. They consist of thin-walled, strongly turgescent tissue, which is sensitive to the force of gravity. When the culm is horizontal or oblique the cells of the node on the side turned towards the earth begin to lengthen; the lower side thus becomes longer, while the upper side is shortened from pressure on the opposite side. Several nodes may share in this process, which goes on until the upper internodes have resumed the vertical. The typical grass stem is hollow, and rigidity is given to it by bands of thick-walled tissue. This structure is adapted for the production of a tough, flexible stem with a minimum expenditure of material. This stem has to last long enough to raise the leaves and inflorescence into the air and be flexible enough to allow swaying in the wind without breaking, which changes the air round the leaves, and thus assists in the process of feeding, and also in the distribution of the pollen, and later of the fruits. This economical manner of growth is

one of the reasons for the success of the family. The leaf consists of a sheath, a ligule, which is a prolongation of the sheath, and helps to prevent water from running down between the sheath and the stem, and a blade. The function of the blade is to carry on the interchange of gases between the plant and the air, from which the plant obtains raw carbonaceous food-stuff, and to give off in the form of vapour the surplus water which has served as a carrier for the raw nitrogenous food-stuff absorbed by the roots and sent up to the leaves. When plants live in dry places or are exposed to dry winds there is a danger of excessive evaporation and consequent withering of the leaves. This is guarded against in various ways. In *Echinocactus*, for instance, the whole structure is altered for this purpose. The leaves disappear, the branches become spines, and the plant becomes a green wax-coated water-reservoir. The grass-leaf effects this without any expensive modification of form or structure by simply rolling up its leaf-surface. Hence the character of the blade often reflects that of the environment, being thin and flat in shade grasses, and narrow, or often rolled, in those exposed to sun, wind or drought. The rolling up is often caused by special motor cells. Some of the cells of the upper epidermis, either next the central rib or between the other ribs, are large and thin-walled and full of sap when distended. These cells are so placed that as they lose water by evaporation they contract and draw together the halves of the blade, or each ribbed longitudinal segment, thus causing infolding or inrolling and protection of the stomata on the concave surface of the leaf. These stomata are often situated in crevices running up the length of the leaf, and the opening of the crevice may be protected further by hairs which interlock when the leaf rolls up. The outer side of the leaf, which is left exposed, is protected by harder tissues. The President promised to deal with the flowers of grasses on a subsequent occasion, and he was heartily thanked for his interesting address.

There will be an excursion to the grounds of Sion House on the 22nd inst. At the next Ordinary Meeting, which will be on October 8th, the first meeting of the new session, Mr. N. E. Brown, A.L.S., will give an address on "The Fertilisation of the Fig."

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OFFICERS AND COMMITTEE.

(*Elected February 1916.*)

President:

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Vice-Presidents:

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D. J. Scourfield, F.Z.S., F.R.M.S.
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Chas. S. Todd.
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Hon. Treasurer:

Frederick J. Perks, 48, *Grove Park*, *Denmark Hill*, *S.E.*, to whom subscriptions should be sent.

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James Burton, 8, *Somali Road*, *West Hampstead*, *N.W.*, to whom all correspondence should be addressed.

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C. F. Rousselet, Curator R.M.S., *Fir Island*, *Mill Hill*, *N.W.*

Hon. Reporter:

R. T. Lewis, F.R.M.S., 25, *Craigerne Road*, *Blackheath*, *S.E.*

Hon. Librarian:

S. C. Akehurst, F.R.M.S., 60, *Bowes Road*, *Palmers Green*, *N.*

Hon. Curator:

C. J. H. Sidwell, F.R.M.S. 46, *Ashbourne Grove*, *Dulwich*, *S.E.*

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A. W. Sheppard, F.Z.S., F.R.M.S., 1, *Vernon Chambers*, *W.C.*

PAST PRESIDENTS.

	Elected
*EDWIN LANKESTER, M.D., F.R.S. . .	July 1865.
*ERNEST HART	,, 1866.
*ARTHUR E. DURHAM, F.R.C.S., F.L.S. .	,, 1867-8.
*PETER LE NEVE FOSTER, M.A. . .	,, 1869.
*LIONEL S. BEALE, M.B., F.R.S. . .	,, 1870-1.
ROBERT BRAITHWAITE, M.D., F.L.S. .	,, 1872-3.
*JOHN MATTHEWS, M.D., F.R.M.S. . .	,, 1874-5.
*HENRY LEE, F.L.S., F.G.S., F.R.M.S., F.Z.S.	,, 1876-7.
*THOS. H. HUXLEY, LL.D., F.R.S. . .	,, 1878.
*T. SPENCER COBBOLD, M.D., F.R.S., F.L.S.	,, 1879.
T. CHARTERS WHITE, M.R.C.S., L.D.S., F.R.M.S.	,, 1880-1.
*M. C. COOKE, M.A., LL.D., A.L.S. . .	,, 1882-3.
*W. B. CARPENTER, C.B., F.R.S. . .	,, 1884.
A. D. MICHAEL, F.L.S., F.R.M.S. . .	,, 1885-6-7.
B. T. LOWNE, F.R.C.S., F.L.S. . . .	Feb. 1888-9.
*Rev. W. H. DALLINGER, LL.D., F.R.S., F.R.M.S.	,, 1890-1-2.
EDWARD MILLES NELSON, F.R.M.S. .	,, 1893-4-5.
*J. G. WALLER, F.S.A.	,, 1896-7.
JOHN TATHAM, M.A., M.D., F.R.M.S. .	,, 1898-9.
GEORGE MASSEE, F.L.S. . .	Feb. 1900-1-2-3.
EDMUND J. SPITTA, L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S. . . .	Feb. 1904-5-6-7.
*E. A. MINCHIN, M.A., F.R.S. .	Feb. 1908-11.

* Deceased.

HONORARY MEMBERS.

Date of Election.

Feb. 17, 1893. Robert Braithwaite, M.D., F.L.S., F.R.M.S. (*Past President*)
26, *Endymion Road, Brixton Hill, S.W.*

Feb. 17, 1893. T. Charters White, M.R.C.S., L.D.S., F.R.M.S. (*Past President*)
59, *Victoria Road South, Southsea.*

Mar. 19, 1897. B. T. Lowne, M.D., F.R.C.S., F.L.S. (*Past President*)
34, *Portland Road, Hove, Sussex.*

May 18, 1906. Dr. Eugène Penard
Rue Töpffer 3, *Geneva.*

Jan. 23, 1912. Alpheus Smith
14, *Leigham Vale, Streatham, S.W.*

April 23, 1912. Fred Enock, F.L.S., F.R.M.S., F.E.S.
54, *St. Mary's Terrace, West Hill, Hastings.*

LIST OF MEMBERS.

Date of Election.

Nov. 24, 1914. Adams, Walter
85a, Rushey Green, Catford, S.E.

Dec. 23, 1913. Ainslie, Maurice Anderson, R.N., B.A., F.R.A.S.
8, Woodville Road, Blackheath, S.E.

Feb. 16, 1906. Akehurst, Sydney Charles, F.R.M.S. (*Hon. Librarian*)
60, Bowes Road, Palmer's Green, N.

April 25, 1916. Aldis, Arthur William
44, Earls Court Square, S.W.

Feb. 19, 1904. Allardice, Lieut. William McDiarmid
St. Endellion, Port Isaac, R.S.O. Cornwall.

May 24, 1910. Allen, William Nassau
"Caerneagh," North Circular Road, Dublin.

Jan. 28, 1913. Allison, Arthur Morris
8, Sidney Road, Beckenham.

Jan. 26, 1915. Andrew, Jas. Grant
62, Grovelands Road, Palmer's Green, N.

Dec. 15, 1899. Angus, H. F., F.R.M.S.
83, Wigmore Street, Cavendish Square, W.

Feb. 25, 1913. Armitage, John Joseph, L.D.S.E.
5, Cavendish Place, W.

June 21, 1907. Arpin, John Edward
131, Castelnau, Barnes, S.W.

Feb. 22, 1889. Ashe, A., F.R.M.S.
55, Warrior Square, Southend-on-Sea.

Feb. 28, 1911. Austin, Henry
Tudor House, 120, *Greenwich Road, Greenwich, S.E.*

Date of Election.

June 4, 1909.	Baddeley, William H. L. 29, *Church Crescent, Church End, Finchley, N.*
April 17, 1903.	Bagshaw, Walter, J.P., F.R.M.S. "*Moorfield,*" *Birkenshaw, near Bradford, Yorks.*
Sept. 26, 1884.	Baker, F. W. Watson, F.R.M.S. 313, *High Holborn, W.C.*
Mar. 16, 1906.	Baker, Henry James 13, *Moorgate Street, E.C.*
April 2, 1909.	Baker, Wilfred E. Watson 313, *High Holborn, W.C.*
Nov. 25, 1913.	Bale, Wm. Urontier, F.R.M.S. 63, *Walpole Street, Kew, Victoria, Australia.*
June 19, 1908.	Banham, Edward Elliott 64, *Queen's Avenue, Church End, Finchley, N.*
May 28, 1912.	Barnard, Edward Jas. 10, *Denver Road, Stamford Hill, N.*
Feb. 25, 1913.	Barnard, Joseph Edwin, F.R.M.S. *Park View, Brondesbury Park, N.W.*
Mar. 19, 1886.	Barnes, W. 23, *Jackson Road, Holloway, N.*
May 28, 1912.	Barratt, Kenneth Franklin "*Bell Moor,*" *Hampstead Heath, N.W.*
May 28, 1912.	Barratt, Thos. Franklin "*Bell Moor,*" *Hampstead Heath, N.W.*
Sept. 27, 1872.	Bartlett, Edward, L.D.S., M.R.C.S.E. 38, *Connaught Square, W.*
Nov. 26, 1912.	Bassett, Ernest Henry "*Pro tem,*" *Amberley Road, Palmer's Green, N.*
June 17, 1892.	Bates, C. 1, *Windsor Road, Denmark Hill, S.E.*
Oct. 18, 1895.	Baugh, J. H. A. 63, *Cambridge Road, Hammersmith, W.*
June 4, 1909.	Baxendale, Frederick G. *Corbally, Arbrookhane, Esher.*
Jan. 16, 1891.	Baxter, W. E., F.R.M.S. 170, *Church Street, Stoke Newington, N.*

Date of Election.	
Oct. 27, 1914.	Beattie, Wm. 8, *Lower Grosvenor Place, S.W.*
Nov. 26, 1875.	Beaulah, John *Albert House, Brigg.*
July 25, 1884.	Beck, C., F.R.M.S. 68, *Cornhill, E.C.*
June 27, 1911.	Bennett, Lionel C. 49, *Erpingham Road, Putney, S.W.*
Feb. 16, 1906.	Bestow, Charles H., F.R.M.S. 43, *Upper Clapton Road, N.E.*
Mar. 28, 1916.	Bevington, Reginald, H. S. 28, *Cannon Street, E.C.*
Oct. 26, 1915.	Bilham, Ernest Q. *Town Hall, Bethnal Green, E.*
June 16, 1905.	Blair, William Nisbet 23, *West Hill, Highgate, N.*
Oct. 2, 1908.	Blockley, Edgar A. 27, *Beechwood Avenue, Kew Gardens.*
May 19, 1899.	Blood, Maurice, M.A., F.C.S., F.R.M.S. 51, *Winchester Avenue, Brondesbury, N.W.*
Feb. 22, 1916.	Bocock, Chas. Hanslope *The Elms, Ashley, Newmarket.*
Jan. 25, 1915.	Boltz, Arthur 21, *Ashbridge Road, Leytonstone.*
Feb. 25, 1913.	Booker, Alfred James 37, *Claremont Road, Highgate, N.*
April 25, 1911.	Bowtell, Alexander Jas. 123, *Dalston Lane, N.E.*
Nov. 23, 1915.	Bradbury, John Geo. 1, *Hogarth Hill, Finchley Road, Hendon, N.W.*
Nov. 15, 1907.	Bradford, William Barnes 65, *Tyrwhitt Road, St. John's, S.E.*
Mar. 24, 1914.	Brand, Felix R. W. 37, *Hatton Garden, E.C.*
Nov. 17, 1905.	Bremner, John Unthank 277, *King Street, Hammersmith, W.*
Jan. 24, 1911.	Bridge, Samuel 28, *Larkhall Rise, Clapham, S.W.*

Date of Election.

Nov. 6, 1908. Broad, John Moxon
2, Nicoll Road, Harlesden, N.W.

Nov. 24, 1914. Brokenshire, Frederick Reardon
7, Hillsboro' Avenue, Pennsylvania, Exeter.

Feb. 23, 1915. Brooke, Chas. Hy. Alfred
159, Sutherland Avenue, W.

May 28, 1912. Brooke, Thos. Robinson
12, Warren Road, Chingford, N.E.

Dec. 4, 1908. Brooks, Theodore, F.R.M.S.
British Vice-Consul, Guantanamo, Cuba.

Dec. 19, 1890. Brough, J. R.
"Eversley," Shepherd's Hill, Highgate, N.

Mar. 15, 1907. Browett, William
"Beaumont," Pearfield Road, Forest Hill, S.E.

May 24, 1910. Brown, Edward George
8, Freke Road, Battersea, S.W.

Jan. 18, 1907. Brown, Nicholas Edward, A.L.S.
6, The Avenue, Kew.

Jan. 28, 1887. Browne, E. T., M.A., F.R.M.S.
Anglefield, Berkhamsted, Herts.

Mar. 18, 1904. Brushfield, N. W.
13, Allfarthing Lane, Wandsworth Common, S.W.

Jan. 15, 1892. Bryce, David (*Vice-President*)
37, Brooke Road, Stoke Newington, N.

May 28, 1912. Bull, Albert Edwd.
3, Canterbury Terrace, Sudbury, Harrow.

May 15, 1908. Bunting, Percival J.
"Lynhurst," Birches Barn Road, Wolverhampton.

Jan. 20, 1905. Burnell, Charles Edward
29, High Street, Shepton Mallet.

Feb. 28, 1913. Burns, Dr. Nesbitt, M.B., B.A., F.R.S.E.
"The Lodge," Highbridge, Somerset.

April 20, 1906. Burrell, T. Leonard
20, Upper Hornsey Rise, Islington, N.

April 28, 1914. Burton-Brown, Gerald Burton, M.D.
Harston, Sidmouth.

Date of Election.

Feb. 19, 1904.	Burton, James (*Hon. Sec.*), *8, Somali Road, West Hampstead, N.W.*
May 26, 1914.	Buttemer, Robt. Wm., F.C.S., M.I.A.E. *St. Mary's, Godalming.*
Feb. 19, 1904.	Butterworth, Arthur Cyrus, F.R.M.S. *Granville, Crowstone Road, Westcliff-on-Sea.*
April 15, 1904.	Caffyn, Charles Henry 32, *Falkland Road, Hornsey, N.*
June 18, 1897.	Campbell, Colney 47, *Selborne Road, Southgate, N.*
Mar. 16, 1906.	Capell, Bruce John, F.R.M.S. 10, *Castelnau, Barnes, S.W.*
Mar. 28, 1914.	Carlile, E. 28, *Chatsworth Road, Croydon.*
Jan. 20, 1905.	Carrington, John *P.O. Box* 48, *East London, South Africa.*
May 24, 1910.	Carruthers, Ferdinand Gilbert 10, *Addison Road, Bedford Park, W.*
Jan. 25, 1910.	Carter, John Arthur 6, *Temple Road, Stowmarket.*
June 17, 1892.	Chaloner, G., F.C.S. *South Street, Colyton, S.O., Devon.*
June 28, 1910.	Charlton, Alfred Edward 13, *Parkhurst Road, Camden Road, N.*
Oct. 26, 1909.	Cheavin, Harold Squire, F.R.M.S. 70, *Somerset Road, Huddersfield.*
April 22, 1913.	Cheshire, Frederic John, F.R.M.S. 23, *Carson Road, Dulwich, S.E.*
Mar. 22, 1878.	Chester, The Very Rev. the Dean of *The Deanery, Chester.*
Dec. 18, 1896.	Chipps, F. W. 201, *Castelnau, Barnes, S.W.*
Jan. 20, 1905.	Christie, John, F.R.M.S. *Henleigh, Kingston Hill, Surrey.*

Date of Election.

Mar. 17, 1905. Clemence, Walter
14, Beckenham Grove, Shortlands.

Jan. 27, 1914. Clibborn, Lt.-Col. John
87, Victoria Street, S.W.

Oct. 18, 1907. Coldwells, William Henry
Redcote, Shirley Road, Wallington.

Oct. 21, 1904. Conrady, Alexander Eugen, F.R.A.S.
23, Flanchford Road, Stamford Brook, W.

Mar. 25, 1913. Cook, John Thomas
216, Clive Road, West Dulwich, S.E.

April 28, 1914. Cooley-Martin, Francis
"Hillside," Portsdown, Cosham, Hants.

Nov. 26, 1912. Coon, Joseph May
"Morwenna," St. Austell.

Jan. 18, 1901. Cox, Thomas N.
104, Tressillian Road, Brockley, S.E.

Jan. 15, 1904. Cox, William
"The Pound," Lingfield, Surrey.

June 19, 1903. Coxhead, G. W.
36, Linthorpe Road, Stamford Hill, N.

Jan. 25, 1910. Crabtree, James Fox, B.A.
40, Brazennose Street, Manchester.

April 27, 1915. Craig, Rev. S. Runsie
"Craigmount," Central Hill, Upper Norwood, S.E.

Nov. 25, 1913. Creese, Edward J. E., F.Z.S., F.R.M.S.
29, Cornford Grove, Balham, S.W.

Nov. 21, 1902. Cressey, Dr. G. H.
Oak Manor, Tonbridge.

Aug. 28, 1868. Crisp, Sir Frank, LL.B., V.P.L.S., B.A., F.R.M.S., F.G.S., F.Z.S.
5, Lansdowne Road, Notting Hill, W.

Nov. 16, 1906. Crosbie, Walter
Kenilworth, Lyonsdown Avenue, New Barnet.

Feb. 16, 1900. Crossland, R. E., A.R.I.B.A.
10, Serjeant's Inn, Fleet Street, E.C.

Mar. 16, 1894. Culshaw, Rev. George H., M.A.
The Rectory, Iver Heath, Bucks.

Date of Election.

Jan. 16, 1903. Curties, C. Lees, jun.
244, *High Holborn, W.C.*

May 18, 1906. Cuzner, Edgar, F.R.M.S.
36, *Trothy Road, Bermondsey, S.E.*

Nov. 18, 1904. Dade, Willoughby Dreyer
13, *Glendinning Avenue, Weymouth.*

Jan. 17, 1908. Dallas, Charles Caldwell, F.R.G.S., F.Z.S.
Eastley Wootton, New Milton, Hants.

Dec. 21, 1906. Darlaston, Herbert William Hutton
31, *Freer Road, Birchfield, Birmingham.*

Feb. 28, 1911. Davidson, John
29, *Federation Road, Abbey Wood, Kent.*

June 16, 1905. Davies, Daniel, F.R.M.S.
12, *Eliot Hill, Blackheath, S.E.*

April 28, 1914. Davies, Daniel Arthur
12, *Eliot Hill, Blackheath, S.E.*

June 24, 1913. Dean, Frank
1, *Langham Street, Portland Place, W.*

May 17, 1901. Deeley, George P.
Moushall, Amblecote, Brierley Hill, Staffordshire.

April 25, 1916. Deey, Rev. Francis, M.A.
St. Bartholomew's Vicarage, South Bermondsey, S.E.

April 19, 1895. Delcomyn, Theo. A., F.R.M.S.
"*Feldheim,*" *Wimbledon Common, S.W.*

Jan. 23, 1912. Dendy, Arthur, D.Sc., F.R.S. (*President*)
Vale Lodge, Hampstead Heath, N.W.

Feb. 23, 1915. Denne, M. T.
23, *Hornsey Lane Gardens, Highgate, N.*

Mar. 22, 1889. Dick, J.
Milber, Victoria Road, Mill Hill, N.W.

Feb. 15, 1907. Dilks, Arthur Charles, B.Sc.
Tardebigge, Bromsgrove.

June 24, 1913. Dinn, Harold H.
72, *Elmwood Road, Herne Hill, S.E.*

June 4, 1909. Dixon, Arthur L.
35, *North Hill, Highgate, N.*

Date of Election.	
June 17, 1892.	Dixon-Nuttall, F. R., F.R.M.S. *"Ingleholme," Eccleston Park, near Prescot, Lancashire.*
Nov. 25, 1913.	Dobell, Henry 74, *Babbacombe Road, Bromley, Kent.*
Oct. 24, 1911.	Downing, Owen Walter 23, *Glenhouse Road, Eltham, Kent.*
Mar. 17, 1899.	Downs, Arthur 2, *Ulverston Road, Walthamstow, E.*
Nov. 23, 1915.	Drake, Arthur Penrhyn, A.M.I.E.E. 83, *Ingram Road, Park, Sheffield.*
Nov. 23, 1909.	Draper, Bernard M. 9, *Pitt Street, Kensington, W.*
Nov. 15, 1901.	Druett, C. R. 330, *Uxbridge Road, W.*
April 27, 1915.	Duncanson, John Richard 41, *Atholl Mansions, S. Lambeth Road, S.W.*
Feb. 25, 1913.	Durrad, John Wm., F.R.A.S. 350, *Fosse Road North, Leicester.*
June 19, 1891.	Earland, Arthur, F.R.M.S. 34, *Granville Road, Watford.*
May 15, 1908.	East, John Holtham 75, *Moorland Road, Weston-super-Mare.*
April 22, 1913.	Edwards, Henry 22, *St. Bartholomew's Road, Reading.*
Oct. 22, 1912.	Edwardes, Seabury *Bhamo, Upper Burma.*
Feb. 21, 1902.	Edwards, Thomas Jarvis 9, *St. Lawrence Road, Brixton, S.W.*
Oct. 22, 1912.	Elliott, Wm. 97, *Devonport Road, Shepherd's Bush, W.*
Mar. 22, 1910.	Ellis, William Neale *The "Pharmacy," Appledore, Devon.*
Nov. 28, 1911.	Emsley, Harold Percy 31, *Victoria Road, Wood Green, N.*
Mar. 24, 1914.	Engleheart, Conrad Wm. 6, *Shaftesbury Villas, Kensington, W.*

Date of Election.	
Nov. 17, 1905.	Evans, Morris B. *"Springwell," Hayes End Road, Middlesex.*
April 27, 1915.	Evans, Roy Gerald 5, *Dean Road, Willesden Green, N.W.*
Dec. 21, 1906.	Fawcett, Henry Hargreave *Thorncombe, near Chard, Somerset.*
June 24, 1913.	Fendick, Ernest Alfred 22, *Finedon Road, Wellingborough, Northants.*
June 16, 1893.	Filer, Frank E. 35, *Dancroft Road, Herne Hill, S.E.*
Feb. 19, 1904.	Finlayson, Daniel *"Redfern," Pellatt Grove, Wood Green, N.*
Feb. 24, 1914.	Finlayson, Raymond 22, *Pellatt Grove, Wood Green, N.*
Nov. 23, 1888.	Flood, W. C. 119, *Highbury Hill, N.*
Mar. 25, 1913.	Ford-Fone, W. Edwin 146, *Palmers Road, New Southgate.*
June 23, 1871.	Freeman, Henry Edward *Walcot, Limes Avenue, New Southgate, N.*
Dec. 16, 1898.	French, Archibald J. 57, *Ermine Road, Lewisham, S.E.*
Jan. 18, 1907.	Fuelling, George Ernest 195, *High Road, Streatham, S.W.*
Feb. 22, 1910.	Fuller, Frederick Charles 7, *Goldington Road, Bedford.*
Nov. 21, 1902.	Fuller, William 24, *Coleford Road, Alma Road, Wandsworth, S.W.*
May 15, 1903.	Gabb, G. H., F.C.S. 83, *Crayford Road, Tufnell Park, N.*
Nov. 25, 1913.	Gamman, Robt. 13, *Park Road, High Barnet.*
Feb. 27, 1912.	Gammon, Geo. Edwd. 6, *Mackintosh Place, Roath, Cardiff.*

Date of Election.

Dec. 15, 1905. Gardner, Edward Lewis
1, Craven Road, Harlesden, N.W.

Jan. 20, 1899. Gardner, William, F.R.M.S.
292, Holloway Road, N.

Dec. 16, 1904. Garnett, Theodore, M.A. Oxon
South Bank, Grassendale, Liverpool.

Jan. 27, 1914. Gee, Harry Arthur
20, Bucklersbury, E.C.

Mar. 28, 1916. Gillies, David
3, Hurst Road, Bexley, Kent.

Mar. 24, 1914. Gingell, Leonard Ralph
8, Grove Crescent, South Woodford.

Mar. 22, 1910. Gonville, Cyril H. K.
"Roslin," Queen's Road, Buckhurst Hill, N.

Feb. 24, 1914. Gooding, Alfred Charles
53, Park Road, Battersea, S.W.

Dec. 28, 1909. Gooding, Henry Cornish
Stowmarket, Suffolk.

April 2, 1909. Gordon, Fred Wm., F.R.M.S.
"Graylands," Augustus Road, Wimbledon Park, S.W.

Feb. 22, 1910. Gordon, John W.
113, Broadhurst Gardens, Hampstead, N.W.

Jan. 25, 1910. Green, Frederick W.
42, Roxboro' Park, Harrow.

Jan. 16, 1903. Green, H. O.
4, Leamington Gardens, Seven Kings.

Jan. 26, 1915. Griffiths, Captain David
"Sunnyside," The Grove, Aldershot.

May 24, 1910. Grundy, James, F.R.M.S.
"Ruislip," Teignmouth Road, Cricklewood, N.W.

June 25, 1912. Gurney, Joseph
Downs Farm, Pinner S.O., Middlesex.

Nov. 28, 1911. Guye, Dr. Paul
12, Rue de Candolle, Geneva, Switzerland.

Nov. 24, 1914. Hamilton, Geo. Clarendon
"The Swallows," Mill Hill, N.W.

Date of Election.

Feb. 22, 1910. Hammond, Alfred Gauntlett
101, *Melody Road, Wandsworth, S.W.*

Jan. 25, 1910. Hammond, Arthur Rashdall
15, *Genoa Road, Anerley, S.E.*

April 26, 1910. Hammond, Leonard Frank
22, *Mercers Road, N.*

Oct. 22, 1886. Hampton, W.
The Manor House, Weston, Staffordshire.

Feb. 23, 1915. Handford, R. E.
41, *Westwood Road, Goodmayes.*

Mar. 28, 1916. Hardcastle, Alfred
17, *Felsham Road, Putney, S.W.*

Nov. 22, 1910. Harris, A. Wellesley, M.R.C.S., etc.
"*Alnwick,*" *Berlin Road, Catford, S.E.*

May 19, 1905. Harris, Charles Poulet, M.D., M.R.C.S., L.R.C.P., F.R.M.S.
192, *Lower Addiscombe Road, Croydon.*

Jan. 27, 1914. Harris, Leslie Edwin
19, *Cheriton Square, Balham, S.W.*

May 25, 1915. Hartley, W. E. T.
5, *Pitt Terrace, Stirling, N.B.*

Dec. 21, 1906. Hasslacher, Charles John
3, *Kensington Park Gardens, W.*

Mar. 28, 1879. Hawkins, C. E.
23, *Dalebury Road, Upper Tooting, S.W.*

June 13, 1914. Hawksley, Chas. Worthington
357, *Oxford Street, W.*

Nov. 26, 1912. Hayward, Leslie Chas.

Feb. 15, 1901. Headley, F. W.
Haileybury College, Hertford.

Jan. 19, 1906. Heath, Charles Emanuel, F.R.M.S.
178, *Loughboro' Road, Brixton, S.W.*

April 20, 1906. Herbert, Robert Henry
6, *Parkhurst Road, Holloway, N.*

Feb. 21, 1908. Heron-Allen, Edward, F.L.S., F.G.S., F.R.M.S., F.R.Met.S., F.Z.S.
33, *Hamilton Terrace, N.W., and Large Acres, Selsey Bill, Sussex.*

Dec. 20, 1901. Hicks, Frederick H.
8, *Belmont Road, Wallington, Surrey.*

Date of Election.

Dec. 22, 1910.	Higginson, George Neale 42, *Bartholomew Road, Camden Town, N.W.*
Nov. 26, 1912.	Hill, Wm., F.G.S. "*The Maples*," *Hitchin.*
Nov. 15, 1895.	Hilton, A. E. 1, *Highwood Avenue, North Finchley, N.*
May 15, 1908.	Hiscott, Thomas Henry, F.R.M.S. 16, *Woodville Road, Ealing, W.*
May 27, 1913.	Hoare, Stanley 17, *Cornwall Terrace, Regent's Park, N.W.*
Dec. 15, 1893.	Holder, J. T. 114, *Pepys Road, New Cross, S.E.*
Feb. 26, 1875.	Holford, Christopher 5, *Northumberland Avenue, Upper Richmond Road, Putney, S.W.*
Dec. 20, 1907.	Holmes, Frederick 217, *Franciscan Road, Tooting, S.W.*
June 25, 1912.	Hook, Gerald Francis 97, *Mortlake Road, Kew Gardens.*
May 27, 1913.	Hook, Reginald Vincent 9, *Barrowgate Road, Chiswick, W.*
Jan. 15, 1904.	Hopkinson, John, F.L.S., F.G.S., F.R.M.S. *Weetwood, Watford.*
Oct. 26, 1866.	Horncastle, Henry "*Lindisaye*," *Woodham Road, Woking.*
April 15, 1898.	Hounsome, John 21, *Edith Road, Plashet Grove, East Ham, E.*
Dec. 4, 1908.	Howard, George *Sitwell Vale, Moorgate, Rotherham, Yorks.*
Oct. 19, 1894.	Howard, R. N., M.R.C.S., F.R.M.S. *The Cape Copper Co., Ookiep, Port Nolloth, Namaqualand, Cape Colony, South Africa.*
Oct. 19, 1894.	Hughes, F. *Wallfield, Reigate.*
Nov. 23, 1909.	Huish, Charles Henry, F.R.M.S. 24, *Champion Grove, Grove Lane, S.E.*

Date of Election.

June 4, 1909. Hunter, John E.
"Strathblane," Park Road, Wallington.

Dec. 20, 1901. Hurrell, Harry Edward
25, *Regent Street, Great Yarmouth.*

Feb. 25, 1913. Hutchin, Chas. Duncan
c/o Meredith & Drew, Ltd., High Street, Shadwell, E.

May 24, 1867. Ingpen, J. E., F.R.M.S.
21, *Wrotham Road, Broadstairs.*

Feb. 16, 1906. Inwards, Richard, F.R.A.S.
6, *Croftdown Road, Highgate Road, N.W.*

Feb. 22, 1916. Jackson, James Joseph
30, *Windsor Road, Wanstead, N.E.*

Feb. 28, 1911. Jacob, Hugh Frederick Dawson, M.I.E.E.
B5, *Clive Buildings, Calcutta.*

Feb. 27, 1912. Jacobs, Reginald

April 26, 1910. Jervis, Rev. Edward S.
St. Peter's Vicarage, Streatham, S.W.

Nov. 24, 1914. Jewell, Harry
23, *Beaty Avenue, Toronto, Canada.*

Nov. 22, 1910. Jewell, Henry
152, *Leathwaite Road, Clapham Common, S.W.*

Nov. 17, 1905. Jones, Arthur Morley
24, *Grove Avenue, Hanwell, W.*

April 26, 1910. Jones, George Fisher
Devonshire House, Osterley Park Road, Southall, W.

Jan. 18, 1907. Jones, Rev. Robert Francis
28, *Douglas Road, Canonbury, N.*

Feb. 22, 1910. Jones, William Llewellyn
Manley Knoll, Helsby, Cheshire.

Feb. 22, 1910. Joshua, Edward Cecil
St. James's Buildings, William Street, Melbourne, Victoria.

Nov. 17, 1905. Karleese, Benjamin
The Dell, Barnt Green, Worcestershire.

Date of Election.	
May 23, 1873.	Karop, G. C., M.R.C.S., F.R.M.S., etc. *Inniscorig, Beltinge Road, Herne Bay.*
Feb. 25, 1913.	Kaufmann, James C., LL.D. 49, *Queen Street, Melbourne.*
June 21, 1907.	Kemp, Francis H. N. C. 15, *Vernon Road, Hornsey, N.*
July 25, 1884.	Kern, J. J. 63, *Queens Road, Beckenham, Kent.*
Nov. 18, 1904.	Kew, H. Wallis 3, *Herndon Road, Wandsworth, S.W.*
June 23, 1914.	King, Chas. Jas. Reeves 64, *Shell Road, Lewisham, S.E.*
Nov. 23, 1915.	King, Geo. W. 163, *Boro' High Street, S.E.*
May 17, 1901.	Kirkman, Hon. Thomas, M.L.C., F.R.M.S. Croftlands, Esperanza, Natal.
May 19, 1905.	Kitchin, Joseph, F.R.M.S. "*Ingleneuk*," 14, *Brackley Road, Beckenham, Kent.*
Mar. 22, 1889.	Klein, S. T., F.R.A.S., F.L.S., F.R.M.S. "*Hatherlow*," *Raglan Road, Reigate.*
Dec. 22, 1914.	Knott, Dr. Frederick "*Karnak*," *Upper Woodcote, Purley.*
Oct. 28, 1913.	Knox Stuart, G. E. Inman 9 *Briardale Gardens, Hampstead, N.W.*
Dec. 28, 1909.	Knox, Sydney W. 61, *Cambridge Street, Hyde Park, W.*
Mar. 24, 1914.	Koch Victor, M.E. 43, *Elgin Avenue, Maida Vale, W.*
Feb. 17, 1905.	Lambert, Charles Alexander *Bank of New South Wales, Warwick, Queensland.*
Jan. 18, 1907.	Larkin, Thomas Gaisford 29, *Thornlaw Road, West Norwood, S.E.*
April 27, 1915.	Lauwers, Walter 51, *Temple Fortune Hill, Hampstead Garden Suburb, N.W.*

Date of Election.	
June 17, 1904.	Lawrence, Frederick George *c/o Lionel Samson & Son, Cliff Street, Fremantle, West Australia.*
Feb. 25, 1913.	Lawrence, Harry John 7, *Norman Road, South Wimbledon, S.W.*
April 26, 1910.	Lawrence, William John 21, *Cambridge Road, Lee, S.E.*
Mar. 16, 1900.	Lawson, Peter "*Jesmond,*" *Nella Road, Fulham Palace Road, S.W.*
Jan. 1, 1909.	Leadbeater, Herbert C. 81, *Elborough Street, Southfields, S.W.*
Jan. 20, 1905.	Lees, Rev. Frederick Clare, 45, *Cavendish Road, Sutton, Surrey.*
Nov. 21, 1902.	Leonard, Edward 14, *Fairview Road, Oxton, Birkenhead.*
Jan. 17, 1908.	Levin, Major Arthur Everard, R.E. (T.) "*The Croft,*" *Bickley, Kent.*
Feb. 22, 1910.	Lewis, Frederic Henry "*Ashmore,*" *King's Avenue, Clapham Park, S.W.*
April 27, 1866.	Lewis, R. T., F.R.M.S. (*Hon. Reporter*) 25, *Craigerne Road, Blackheath, S.E.*
Nov. 25, 1913.	Liddon, Capt. Matthew Robert 12, *Kensington Court, W.*
June 26, 1868.	Lindley, Sir Wm. H., M.Inst.C.E., F.G.S. 29, *Blittersdorffs Platz, Frankfort-on-Main.*
Mar. 24, 1914.	Lloyd, Francis Wm. 85, *Gracechurch Street, E.C.*
Dec. 23, 1913.	Lock, Thos. Benjn. 78, *Riggindale Road, Streatham, S.W.*
Mar. 23, 1915.	Longmire, J. 23, *Furnival Street, E.C.*
Oct. 27, 1914.	Loxton, Samuel E., F.R.A.S. "*Icknield,*" *Little Aston, nr. Sutton Coldfield.*
May 25, 1883.	Mainland, G. E., F.R.M.S. 14, *The Norton, Tenby, South Wales.*

Date of Election.	
Nov. 24, 1914.	McTavish, Alex. *Cowley Grove Cottage, Uxbridge.*
Nov. 26, 1912.	Mardon, Daniel Arthur *Avon Cottage, Grange Road, Bishops Stortford.*
Jan. 24, 1911.	Marsh, George Robertson, M.A. *Mallards Close, Twyford, near Winchester, Hants.*
Feb. 15, 1895.	Marshall, William John, F.R.M.S. 15, *Elms Road, Dulwich Village, S.E.*
May 18, 1906.	Martin, William *"Kethlen," Burgh Heath, Epsom, Surrey.*
Nov. 28, 1911.	Martin, Wm. Julius
Jan. 15, 1892.	Maw, W. H., F.R.M.S., F.R.A.S. 18, *Addison Road, Kensington, W.*
Mar. 28, 1911.	Maxwell, Edward Kelly, B.A. *H.M. Patent Office, W.C.*
May 19, 1893.	Merlin, A. A. C. Eliot, F.R.M.S. *British Consulate, Volo, Greece.*
Oct. 18, 1907.	Mestayer, Richard L., M.I.C.E., F.R.M.S. *Lambton Quay, Wellington, New Zealand.*
July 27, 1877.	Michael, A. D., F.L.S., F.Z.S., F.R.M.S. *The Warren, Studland, near Wareham, Dorset.*
Feb. 25, 1913.	Mills, Fdk. Wm., F.R.M.S. *Thornleigh Edgerton, Huddersfield.*
Jan. 20, 1905.	Milne, William 70, *Beech Grove Terrace, Aberdeen.*
Oct. 18, 1901.	Moore, Harry, F.R.M.S. 12, *Whiston Grove, Moorgate, Rotherham, Yorks.*
July 26, 1878.	Morland, Henry *Cranford, near Hounslow.*
June 4, 1909.	Mortimer, Hugh Hamilton 20, *Birchin Lane, E.C.*
Jan. 16, 1891.	Muiron, C. 49, *Chatsworth Road, Brondesbury, N.W.*
Dec. 23, 1913.	Mumford, Frank Septimus *Belmont, Doncaster.*

Date of Election.	
Nov. 22, 1910.	Mummery, J. Howard, M.R.C.S. *Islips Manor, Northolt, Middlesex.*
June 16, 1905.	Myles, James Cellars 53, *Carlyle Road, Manor Park, S. Essex.*
Jan. 27, 1914.	Nall, Rev. Geo. Herbert, M.A., F.R.M.S. 18, *Deans Yard, Westminster, S.W.*
Mar. 24, 1876.	Nelson, E. M., F.R.M.S. *Beckington, Bath.*
Feb. 15, 1907.	Newman, Charles Arnold *Oundle, Northants.*
May 27, 1913.	Newmarch, Edgar Ribton 4, *The Drive, Walthamstow, N.E.*
Jan. 26, 1872.	Newton, E. T., F.R.S., F.G.S. *Florence House*, 13, *Willow Bridge Road, Canonbury, N.*
Jan. 17, 1908.	Nicholson, Alfred 19, *Victoria Road, Salisbury.*
June 23, 1914.	Norman, Geoffrey 8, *Cliffords Inn, E.C.*
Nov. 28, 1911.	Nutt, Hy. Francis 51, *Gurdon Road, Charlton, S.E.*
Feb. 25, 1913.	Oatley, Wm. *Badcox, Frome*
Feb. 16, 1900.	O'Donohoe, T. A. 8, *Myrtle Road, Acton, W.*
Jan. 24, 1879.	Offord, J. M., F.R.M.S. 3, *Cleveland Gardens, West Ealing, W.*
Dec. 22, 1876.	Ogilvy, C. P., F.L.S. *Sizewell House, Leiston, near Saxmundham, Suffolk.*
May 17, 1907.	Ogilvy, J. Wilson, F.R.M.S. 18, *Bloomsbury Square, W.C.*
Nov. 15, 1907.	Oke, Alfred William, B.A., LL.M. 32, *Denmark Villas, Hove.*
June 23, 1914.	Oldershaw, Martin Herbert 12, *Perham Road West Kensington, W.*
Nov. 18, 1892.	Orfeur, Frank, F.R.M.S. 91, *Effra Road, Brixton, S.W.*

Date of Election.

April 23, 1912. Owen, Wm. Hy.
19, Home Park Road, Wimbledon.

Dec. 27, 1867. Oxley, Frederick, F.R.M.S.
c/o A. E. Linton, Esq., Box 9, P.O., Nairobi, British East Africa.

Dec. 18, 1903. Oxley, F. J., M.R.C.S.
1, Dock Street, E.

Feb. 27, 1912. Palmer, Hy., J.P., F.R.G.S.
1, Pelaw Terrace, Durham.

Nov. 25, 1913. Panichelli, Frank
7, Rowan Road, Hammersmith, W.

April 10, 1910. Parfitt, Edward William
7, Gatcombe Road, Tufnell Park, N.

Feb. 25, 1913. Parrott, Fdk. Wm.
"Morningside," Albert Road, Hale, Cheshire.

Oct. 27, 1871. Parsons, F. A., F.R.M.S.
15, Osborne Road, Stroud Green, N.

Dec. 16, 1904. Patterson, George
20, Madrid Road, Castlenau, Barnes, S.W.

Jan. 18, 1901. Paulson, Robert, F.L.S., F.R.M.S.
"Glenroy," Cecil Park, Pinner, Middlesex.

May 24, 1867. Pearson, John
40, Maida Vale, W.

May 20, 1904. Perks, Frederick John (*Hon. Treasurer*)
48, Grove Park, Denmark Hill, S.E.

Jan. 18, 1907. Perry, Francis Gough
2, The Cloisters, Gordon Square, W.C.

May 26, 1914. Peter, Henry Turing
15, Hanover Square, W.

Mar. 17, 1905. Phipps, William Joseph
132, Pinner Road, Oxhey, Herts.

Nov. 15, 1895. Pillischer, J., F.R.M.S.
88, New Bond Street, W.

April 25, 1910. Pinchin, Ernest Alfred, B.Sc.
4, Gleneldon Road, Streatham, S.W.

Nov. 26, 1912. Pitt, Edward
Madeley Ho., Gerrard's Cross, Bucks.

Date of Election.

Jan. 15, 1904. Pledge, John H., F.R.M.S. (*Hon. Assistant Secretary*)
72, *Nibthwaite Road, Harrow.*

Nov. 23, 1883. Plowman, T.
Nystuen Lodge, Bycullah Park, Enfield.

Sept. 21, 1894. Pollard, Jonathan, F.R.M.S.
10, *Porteus Road, Paddington Green, W.*

May 18, 1900. Poser, M., F.R.M.S.
St. Paul's Street, Rochester, N.Y.

June 21, 1895. Poulter, Christopher S.
Mount Lodge, Parkhurst Road, Bexley, Kent.

May 17, 1901. Powell, David, M.A., F.R.M.S.
Overstrand, Grove Park Road, Chiswick, W.

July 7, 1865. Powell, Thomas H., F.R.M.S.
Emsdale, Greenham Road, Muswell Hill, N.

Dec. 20, 1907. Pratt, John Edwin
6, *Heathfield Terrace, Seven Kings, Essex.*

June 22, 1915. Price, Reginald A.
11*a*, *Holland Road, Brixton, S.W.*

Nov. 26, 1912. Pulford, Herbert, M.A., etc.
3, *Ambleside Avenue, Streatham, S.W.*

Nov. 6, 1908. Quick, Albert Hedley
"*Inverness,*" *Malvern Road, Thornton Heath.*

Jan. 18, 1901. Radley, Percy E., F.R.M.S.
30, *Foxgrove Road, Beckenham, Kent.*

Nov. 25, 1913. Ramsay, Ernest Wm., P.A.S.I.
16, *Whiteley Road, Upper Norwood, S.E.*

Mar. 28. 1916. Rasquin, Georges
46, *Cunningham Park, Harrow-on-the-Hill.*

Nov. 16, 1906. Reid, Duncan J., M.B., C.M.
20, *Blakesley Avenue, Ealing.*

Mar. 20, 1896. Rheinberg, Julius, F.R.M.S.
23, *The Avenue, Brondesbury Park, N.W.*

Mar. 23, 1915. Ribbons, Joseph Lovelace
"*Greenhill,*" *Reynolds Road, Beaconsfield.*

Date of Election.	
Sept. 18, 1891.	Richards, F. W. 104, *St. Luke Street, Montreal, Canada.*
Oct. 2, 1908.	Richards, William *Heather Brae, Maybury Hill, Woking.*
Jan. 18, 1901.	Richardson, John 28, *Beaumont Avenue, Richmond, Surrey.*
June 21, 1901.	Robertson, Sir Helenus R., F.R.M.S. *Upton Grange, Chester.*
Mar. 15, 1907.	Robertson, James Alexander, F.R.M.S. *Sunnyside, Fleetwood.*
April 28, 1914.	Robotham, Fras. Edward 48, *Lillieshall Road, Clapham, S.W.*
Nov. 16, 1900.	Rogers, G. H. J., F.R.M.S. 55, *King Street, Maidstone.*
June 4, 1909.	Rolph, Frank *Harts Stables, Woodford Green, E.*
Jan. 25, 1884.	Rosseter, T. B., F.R.M.S. *East Kent Club, Canterbury.*
Jan. 26, 1883.	Rousselet, Charles F. (*Vice-President and Hon. Secretary for Foreign Correspondence*), Curator R.M.S. *Fir Island, Mill Hill, N.W.*
Nov. 26, 1912.	Row, Rd. Wm. Harold 36, *Lexham Gardens, Kensington, S.W.*
Nov. 18, 1904.	Rowley, Frederick Richard, F.R.M.S. 8, *Pinhoe Road, Heavitree, Exeter.*
April 27, 1888.	Russell, J. 16, *Blacket Place, Newington, Edinburgh.*
Mar. 24, 1914.	St. George, Harry A. 112, *Albany Street, Regent's Park, N.W.*
April 2, 1909.	Saxton, Thomas R., A.M.I.C.E., F.R.M.S. 43, *East Bank, Stamford Hill, N.*
Nov. 28, 1911.	Schmerl, Augustus 34, *St. Gabriel's Road, Cricklewood, N.W.*
June 23, 1914.	Scott, Wm. Hy. 63, *Fellows Road, S. Hampstead, N.W.*
June 20, 1890.	Scourfield, D. J., F.Z.S., F.R.M.S. (*Vice-President*) 63, *Queen's Road, Leytonstone, E.*

Date of Election.	
May 20, 1898.	Sears, Robert S. W. 1, *Lisson Grove, N.W.*
Jan. 27, 1914.	Shelley, Geo. Hallett 51, *Champion Grove, Denmark Hill, S.E.*
Nov. 25, 1913.	Shepherd, Benjamin *Fir Cottage, Oak Lane, Bounds Green, N.*
Dec. 28, 1909.	Shephard, John *Clark Street, South Melbourne, Victoria.*
May 26, 1876.	Shepheard, Thomas, F.R.M.S. *Kingsley, Bournemouth West.*
June 21, 1907.	Sheppard, Alfred William, F.Z.S., F.R.M.S. (*Hon. Editor*) 1, *Vernon Chambers, W.C.*
Jan. 28, 1913.	Sheppard, Edwd. Jas., F.R.M.S. 137, *Kennington Road, S.E.*
Mar. 25, 1913.	Shuckard, David Hy. 14, *Walerand Road, Lewisham, S.E.*
Feb. 28, 1911.	Sidebottom, Henry "*Woodstock,*" *Syddal Park, Bramhall, Cheshire.*
June 19, 1896.	Sidwell, Clarence J. H., F.R.M.S. (*Hon. Curator*) 46, *Ashbourne Grove, Dulwich, S.E.*
Feb. 22, 1910.	Simpson, Norman Douglas *Carlton Lodge, Wellington Road, Bournemouth.*
Oct. 21, 1904.	Smith, Arthur Edgar "*Helios,*" 71, *Fox Lane, Palmer's Green, N.*
Mar. 25, 1870.	Smith, F. L. 49, *Belvedere Road, Upper Norwood, S.E.*
Mar. 17, 1899.	Smith, Frank P. 2, *King's Villas, Chase Road, Southgate.*
Mar. 17, 1905.	Smith, Frederick 13, *Rye Hill Park, Peckham Rye, S.E.*
Nov. 18, 1898.	Smith, Thomas J., F.R.M.S. c/o *W. Watson & Sons*, 313, *High Holborn, W.C.*
Jan. 15, 1892.	Soar, C. D., F.L.S., F.R.M.S. 37, *Dryburgh Road, Putney, S.W.*

Date of Election.	
Feb. 23, 1915.	Sollis, Wm. Powell 26, *Croxley Road, Maida Hill, W.*
April 21, 1899.	Spitta, Edmund J., L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S. (*Vice-President*) 41, *Ventnor Villas, Hove, Brighton.*
April 21, 1899.	Spitta, Harold R. D., M.D., M.R.C.S., L.R.C.P., D.P.H. 12, *Bolton Street, Mayfair, W.*
Jan. 15, 1904.	Sprague, T. B., LL.D. *West Holme, Woldingham, Surrey.*
Jan. 28, 1913.	Spry, Lt. Robt., R.N., F.R.M.S. 83, *Mount Gold Road, Plymouth.*
Jan. 18, 1907.	Stahl, Arthur 11, *Scotts Avenue, Shortlands, Kent.*
Jan. 25, 1916.	Stephanides, Theodore 72, *Westbourne Terrace, W.*
Nov. 27, 1885.	Stevenson, G. T. *Ravenscourt, Haling Park Road, South Croydon.*
June 18, 1897.	Still, Arthur L. *Roslyn, Dower Avenue, Wallington.*
Nov. 16, 1894.	Stokes, William B. 212, *Notre Dame Street, West Montreal.*
Dec. 15, 1893.	Sturt, Gerald "*Lismore*," *Cavendish Road, Weybridge.*
Dec. 17, 1875.	Swift, M. J., F.R.M.S. 6, *Aylestone Avenue, Brondesbury, N.W.*
Dec. 28, 1915.	Syer, John *Stanmore Hill, Middlesex.*
Nov. 28, 1879.	Tasker, J. G. 30, *Junction Road, Upper Holloway, N.*
Oct. 16, 1896.	Taverner, Henry, F.R.M.S. 319, *Seven Sisters Road, Finsbury Park, N.*
Feb. 17, 1905.	Taylor, Thomas George *Ballaclague, Ellington Park Road, Ramsgate.*
Mar. 28, 1916.	Tennant, John, M.A. 19, *The Boltons, S.W.*

Date of Election.

Dec. 22, 1865. Terry, John
8, *Hopton Road, Coventry Park, Streatham, S.W.*

Mar. 28, 1916. Thomas, Reginald Walter
15, *Ambrose Avenue, Golders Green.*

Mar. 26, 1912. Tibble, Bertie Wallace
27, *St. Paul's Road, Canonbury, N.*

June 24, 1913. Tierney, Clarence M. S., B.Sc., F.R.M.S.
"Netherton," Coulsdon, Surrey.

May 16, 1902. Tilling, George, F.R.M.S.
"Grasmere," Rydal Road, Streatham, S.W.

Nov. 25, 1913. Tilling, Wm. Geo.
20, *Streathbourne Road, Upper Tooting, S.W.*

Nov. 24, 1914. Tindall, Wm. B.
39, *St. Mary Street, Toronto, Canada.*

Jan. 25, 1910. Todd, Charles Stephen
25, *Hanover Road, Tottenham, N.*

Feb. 27, 1912. Tomlinson, Edwd. Theodore
8, *St. George's Square, S.W.*

Nov. 26, 1912. Tonkin, Thos. S.
Bramley Avenue, Coulsdon, Surrey.

April 25, 1916. Topsent, Prof. Emile
Faculté des Sciences Dijon (Cote d'or), France.

Dec. 21, 1894. Traviss, Will. R.
42, *Winchester Avenue, Brondesbury, N.W.*

Feb. 25, 1913. Trotman, Alex. Chas.
28, *Gubyon Avenue, Herne Hill, S.E.*

Mar. 5, 1909. Troughton, Henry George
3, *New Court, Lincoln's Inn, W.C.*

June 17, 1892. Turner, C.
20, *Minster Road, Cricklewood, N.W.*

May 25, 1915. Tutt, John Francis Donald, F.R.C.V.S.
"Rothiemurchus," St. Cross, Winchester.

Feb. 25, 1913. Tyas, Rev. Vetranio
12, *Felstead Road, Wanstead, N.E.*

Jan. 24, 1914. Walker, Arthur
306, *South Lambeth Road, S.W.*

Date of Election.

July 25, 1873. Walker, J. S.
6, *Warwick Road, Upper Clapton, N.E.*

Nov. 22, 1910. Watts, Geo. W.
103, *Haverstock Hill, N.W.*

June 16, 1899. Wedeles, James, F.R.M.S.
231, *Flinders Lane, Melbourne, Australia.*

Mar. 20, 1908. West, Joshua Cobbett
"*Holly Cottage,*" *Church Street, Sunbury-on-Thames.*

Feb. 25, 1876. Wheeler, George

Jan. 25, 1910. Whitehead, Henry, B.Sc. Lond.
23, *Downie Terrace, Murrayfield, Edinburgh.*

Nov. 26, 1912. Whitteron, Fred.
Toorak Avenue, Kooyong, nr. Melbourne, Victoria.

Dec. 4, 1908. Wilkins, Thomas Smith
Eversley, Uttoxeter.

Nov. 23, 1877. Williams, G. S.
Tor Hill, Kingskerswell, Devon.

Nov. 24, 1914. Williams, Rev. John B.
"*The Limes,*" *Exminster, Exeter.*

April 27, 1915. Williamson, Wm.
79, *Morningside Drive, Edinburgh.*

Jan. 19, 1906. Wilson, Joseph, F.R.M.S.
3, *West Park Road, Kew Gardens, S.W.*

Feb. 27, 1912. Wood, Fredk. Geo.
161, *Walworth Road, S.E.*

Dec. 20, 1895. Wood, Walter J., F.R.M.S.
"*Ernecroft,*" *Abbey Road, Grimsby.*

Nov. 16, 1894. Wooderson, Edwin
"*Königsfeld,*" 39, *Dartmouth Road, Brondesbury, N.W.*

Mar. 15, 1907. Worssam, Cecil
17, *Grafton Road, Bedford.*

Jan. 18, 1907. Wright, Joseph Pepper
c/o Messrs. Davidson, Boules, Ld., 86, *Wellington Street, West Toronto, Canada.*

Date of Election.

Feb. 21, 1902.	Wyatt, Edward *Gordonia, Gloucester Road, Norbiton, Kingston.*
Jan. 18, 1901.	Wykes, William 7, *Plaistow Park Road, Plaistow, Essex.*
Mar. 24, 1914.	Yermoloff, His Excellency Nicholas, K.C.V.O. 3, *Whitehall Court, S.W.*
Nov. 23, 1888.	Young, G. W., F.G.S. 20, *Grange Road, Barnes, S.W.*

NOTICE.

Members are requested to give early information to the Treasurer of any change of residence, so as to prevent miscarriage of Journals and Circulars.

List of Exchanges and of Societies, etc., which Receive the Journal.

American Microscopical Society, T. W. Galloway, Secretary, Beloit College, Beloit, Wisconsin, U.S.A.

Bausch & Lomb Optical Company, Publication Department, Rochester, N.Y., U.S.A.

Bergens Museums Bibliothek, Bergen, Norway.

Birkbeck College, Bream's Buildings, Chancery Lane, W.C.

Birmingham Natural History and Philosophical Society, Norwich Union Chambers, Congreve Street, Birmingham.

Botanical Society of Edinburgh (The Curator), The Botanic Gardens, Edinburgh.

Botanisches Centralblatt, c/o Dr. J. P. Lotsy, Spaarne 17, Haarlem, Holland.

Brighton and Hove Natural History Society, c/o The Public Library, Brighton.

Bristol Naturalists' Society (The Librarian), 5, Lansdown Place, Clifton, Bristol.

British Association for the Advancement of Science, Burlington House, London, W.

Canadian Institute, W. H. Vandersmitten, Esq., Secretary, 46, Richmond Street East, Toronto, Canada.

Concilium Bibliographicum, Zürich-Neumünster, Switzerland.

Croydon Natural History and Scientific Society (The Secretary), Public Hall, Croydon.

Dohrn, Prof. Reinhart, The Zoological Station, Naples.

"English Mechanic," 5, Effingham House, Arundel Street, W.C.

Entomological Society, 11, Chandos Street, Cavendish Square, W.

Essex Field Club, Essex Museum of Natural History, Stratford, Essex.

Geologists' Association (The Librarian), University College, Gower Street, W.C.

Herts Natural History Society, c/o Daniel Hill, Esq., "Herga," Watford, Herts.

Historical and Scientific Society of Manitoba, Winnipeg, Canada.

Horniman Museum, Forest Hill, S.E. (The Curator).

Hull Scientific and Field Naturalists' Club, Royal Institution, Hull.

Illinois State Laboratory of Natural History (Library), Urbana, Ill., U.S.A.

"Knowledge," The Knowledge Publishing Co., Ltd., 42, Bloomsbury Square, W.C.

Leicester Literary and Philosophical Society, Dr. Stracey, Hon. Librarian, Priory Lodge, New Walk, Leicester.

Library, Bureau of Science, Manila, Philippines.

Linnean Society, Burlington House, Piccadilly, W.

Literary and Philosophical Society of Manchester (The Librarian), 36, George Street, Manchester.

Lloyd Library, Cincinnati, Ohio, U.S.A.

Manchester Microscopical Society, J. E. Storey, Esq., 26, Grosvenor Road, Whalley Range, Manchester.

Microscopical Society of Liverpool, 19, Hockins Hey, Liverpool.

Missouri Botanical Garden, St. Louis, Mo., U.S.A.

Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne (The Librarian), Hancock Museum, Barras Bridge, Newcastle-upon-Tyne.

Natural History Branch of the British Museum (The Librarian), South Kensington, W.
Natural History Society of Glasgow (The Librarian), 207, Bath Street, Glasgow.
"Nature" (The Editor), St. Martin's Street, W.C.
Netherlands Zoological Society, Zoological Station, Helder, Holland.
"Nuova Notarisia," c/o Prof. G. B. De Toni, Université Royale de Modena, Modena, Italy.
"Nyt Magazin for Naturaidenskaberne," c/o Prof. Dr. N. Wille, Botan. Garten, Christiania.

Optical Society (The Hon. Librarian), 39, Victoria Street, S.W.

Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.
Philadelphia Academy of Natural Sciences, Philadelphia, Pa., U.S.A.
Philippine Exposition Board, Calle General Solano 384, Manila, Philippine Islands.

R. Scuola Superiore di Agricoltura, Portici, Italy.
Royal Dublin Society, Leinster House, Dublin.
Royal Institute of Cornwall, Truro.
Royal Institution, 21, Albemarle Street, W.
Royal Society of Medicine, 1, Wimpole Street, W.
Royal Microscopical Society, 20, Hanover Square, W.
Royal Society, Burlington House, Piccadilly, W.
Royal Society of New South Wales, Sydney.
Royal Society of Arts, John Street, Adelphi, W.C.

Smithsonian Institution, Washington, D.C.
Smithsonian Institution (United States National Museum), c/o Wm. Wesley & Son, 28, Essex Street, Strand.
Société Belge de Microscopie.
Société Botanique Italienne, Florence, Italy.

Tempère, Mons. J., Grèz-sur-Loing, par Bourron, Seine et Marne.

University of California Library (Exchange Department), c/o Wm. Wesley & Son, 28, Essex Street, Strand, London, W.C.

Victoria, Australia, Field Naturalists' Club of. A. D. Hardy, Hon. Secretary.

Wagner Free Institute, Montgomery Avenue and 17th Street, Philadelphia, U.S.A.

Wesenberg-Lund, Dr., Slotsgade, Hillerod, Denmark.

Wisconsin Academy of Sciences, Arts, and Letters (Exchange Secretary), Madison, Wis., U.S.A.

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(Elected February 1918.)

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Chas. S. Todd.
J. Wilson, F.R.M.S.

Hon. Treasurer:

Frederick J. Perks, 48, *Grove Park, Denmark Hill, S.E.*5, to whom subscriptions should be sent.

Hon. Secretary:

James Burton, 8, *Somali Road, West Hampstead, N.W.*2, to whom all correspondence should be addressed.

Hon. Sec. for Foreign Correspondence:

C. F. Rousselet, Curator R.M.S., 4, *St. Matthew's Drive, St. Leonards-on-Sea.*

Hon. Reporter:

Hon. Librarian:

A. George, "*Clovelly,*" *Beresford Road, Harrow, Middlesex.*

Hon. Curator:

C. J. H. Sidwell, F.R.M.S. 46, *Ashbourne Grove, Dulwich, S.E.*22

Hon. Editor:

A. W. Sheppard, F.R.M.S., 1, *Vernon Chambers, W.C.*1.

PAST PRESIDENTS.

	Elected
*EDWIN LANKESTER, M.D., F.R.S.	July 1865.
*ERNEST HART	,, 1866.
*ARTHUR E. DURHAM, F.R.C.S., F.L.S.	,, 1867-8.
*PETER LE NEVE FOSTER, M.A.	,, 1869.
*LIONEL S. BEALE, M.B., F.R.S.	,, 1870-1.
*ROBERT BRAITHWAITE, M.D., F.L.S.	,, 1872-3.
*JOHN MATTHEWS, M.D., F.R.M.S.	,, 1874-5.
*HENRY LEE, F.L.S., F.G.S., F.R.M.S., F.Z.S.	,, 1876-7.
*THOS. H. HUXLEY, LL.D., F.R.S.	,, 1878.
*T. SPENCER COBBOLD, M.D., F.R.S., F.L.S.	,, 1879.
*T. CHARTERS WHITE, M.R.C.S., L.D.S., F.R.M.S.	,, 1880-1.
*M. C. COOKE, M.A., LL.D., A.L.S.	,, 1882-3.
*W. B. CARPENTER, C.B., F.R.S.	,, 1884.
A. D. MICHAEL, F.L.S., F.R.M.S.	,, 1885-6-7.
B. T. LOWNE, F.R.C.S., F.L.S.	Feb. 1888-9.
*Rev. W. H. DALLINGER, LL.D., F.R.S., F.R.M.S.	,, 1890-1-2.
EDWARD MILLES NELSON, F.R.M.S.	,, 1893-4-5.
*J. G. WALLER, F.S.A.	,, 1896-7.
JOHN TATHAM, M.A., M.D., F.R.M.S.	,, 1898-9.
*GEORGE MASSEE, F.L.S.	Feb. 1900-1-2-3.
EDMUND J. SPITTA, L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S.	Feb. 1904-5-6-7.
*E. A. MINCHIN, M.A., F.R.S.	Feb. 1908-11.
ARTHUR DENDY, D.Sc., F.R.S.	Feb. 1912-16.

* Deceased.

HONORARY MEMBERS.

Date of Election.

Mar. 19, 1897. B. T. Lowne, M.D., F.R.C.S., F.L.S. (*Past President*)
34, *Portland Road, Hove, Sussex.*

May 18, 1906. Dr. Eugène Penard
Rue Töpffer 3, *Geneva.*

Feb. 12, 1918. Thomas H. Powell, F.R.M.S.
"*Emsdale,*" *Greenham Rd., Muswell Hill, N.*10.

LIST OF MEMBERS.

Date of Election.

Mar. 12, 1918. Adams, Basil Albert
R.E. Experimental Station, Porton, Salisbury.

Nov. 24, 1914. Adams, Walter
85*a*, *Rushey Green, Catford, S.E.*6.

Dec. 23, 1913. Ainslie, Maurice Anderson, R.N., B.A , F.R.A.S.
8, *Woodville Road, Blackheath, S.E.*3.

Feb. 16, 1906. Akehurst, Sydney Charles, F.R.M.S.
60, *Bowes Road, Palmer's Green, N.*13.

Oct. 23, 1917. Alabaster, Alfred William
5, *Holland Road, Peverill, Plymouth.*

April 25, 1916. Aldis, Arthur William
*Kingsley Hotel, Hart Street, W.C.*1.

Feb. 19, 1904. Allardice, Capt. William McDiarmid
St. Endellion, Port Isaac, R.S.O. Cornwall.

May 24, 1910. Allen, William Nassau
"Caerneagh," North Circular Road, Dublin.

Jan. 28, 1913. Allison, Arthur Morris
49, *Southdown Avenue, Brighton.*

Jan. 26, 1915. Andrew, Jas. Grant
62, *Grovelands Road, Palmer's Green, N.*13.

Dec. 15, 1899. Angus, H. F., F.R.M.S.
83, *Wigmore Street, Cavendish Square, W.*1.

Nov. 13, 1917. Ardaseer, Gustasp, F.R.P.S.
2, *Dynevor Road, Richmond, Surrey*

Feb. 25, 1913. Armitage, John Joseph, L.D.S.E.
5, *Cavendish Place, W.*1.

June 21, 1907. Arpin, John Edward
131, *Castelnau, Barnes, S.W.*13

Date of Election.	
Feb. 22, 1889.	Ashe, A., F.R.M.S. *55, Warrior Square, Southend-on-Sea.*
April 17, 1903.	Bagshaw, Walter, J.P., F.R.M.S. *"Moorfield," Birkenshaw, near Bradford, Yorks.*
Sept. 26, 1884.	Baker, F. W. Watson, F.R.M.S. 313, *High Holborn, W.C.*1.
Mar. 16, 1906.	Baker, Henry James 13, *Moorgate Street, E.C.*2.
April 2, 1909.	Baker, Wilfred E. Watson 313, *High Holborn, W.C.*1.
Nov. 25, 1913.	Bale, Wm. Mountier, F.R.M.S. 83, *Walpole Street, Kew, Victoria, Australia.*
June 19, 1908.	Banham, Edward Elliott 38, *Harboro' Road, Kingsthorpe, Northampton.*
May 28, 1912.	Barnard, Edward Jas. 10, *Denver Road, Stamford Hill, N.*16.
Feb. 25, 1913.	Barnard, Joseph Edwin, F.R.M.S. *Park View, Brondesbury Park, N.W.*6.
Mar. 19, 1886.	Barnes, W. 23, *Jackson Road, Holloway, N.*7.
May 28, 1912.	Barratt, Thos. Franklin *"Bell Moor," Hampstead Heath, N.W.*3.
Nov. 26, 1912.	Bassett, Ernest Henry 43, *Amberley Road, Palmer's Green, N.*13.
June 17, 1892.	Bates, C. 1, *Windsor Road, Denmark Hill, S.E.*5.
Oct. 18, 1895.	Baugh, J. H. A. 63, *Cambridge Road, Hammersmith, W.*6.
June 4, 1909.	Baxendale, Frederick G. *Corbally, Arbrook Lane, Esher.*
Jan. 16, 1891.	Baxter, W. E., F.R.M.S. 170, *Church Street, Stoke Newington, N.*16.
Oct. 27, 1914.	Beattie, Wm. 8, *Lower Grosvenor Place, S.W.*1.
Nov. 26, 1875.	Beaulah, John *Albert House, Brigg.*
July 25, 1884.	Beck, C., F.R.M.S. 68, *Cornhill, E.C.*3.

Date of Election.

June 27, 1911. Bennett, Lionel C.
49, *Erpingham Road, Putney, S.W.*15.

Feb. 16, 1906. Bestow, Charles H., F.R.M.S.
43, *Upper Clapton Road, E.*5.

Mar. 28, 1916. Bevington, Reginald, H. S.
28, *Cannon Street, E.C.*4.

Oct. 26, 1915. Bilham, Ernest Q.
*Town Hall, Bethnal Green, E.*2.

Feb. 27, 1917. Billinghurst, Humphrey Godwin
76, *Lebanon Gardens, Wandsworth, S.W.*18.

Nov. 13, 1917. Birch, Wilfrid John
Pte 523335, 6th San. Sect., Moore Barracks Hospital, Shorncliffe.

June 16, 1905. Blair, William Nisbet
23, *West Hill, Highgate, N.*6.

Oct. 2, 1908. Blockley, Edgar A.
27, *Beechwood Avenue, Kew Gardens.*

May 19, 1899. Blood, Maurice, M.A., F.C.S., F.R.M.S.
51, *Winchester Avenue, Brondesbury, N.W.*6.

Feb. 22, 1916. Bocock, Chas. Hanslope
The Elms, Ashley, Newmarket.

Jan. 25, 1915. Boltz, Arthur
21, *Ashbridge Road, Leytonstone, E.*11.

Feb. 25, 1913. Booker, Alfred James
37, *Claremont Road, Highgate, N.*6.

April 25, 1911. Bowtell, Alexander Jas.
123, *Dalston Lane, E.*8.

Nov. 23, 1915. Bradbury, John Geo.
1, *Hogarth Hill, Finchley Road, Hendon, N.W.*4.

Nov. 15, 1907. Bradford, William Barnes
54, *Lombard Street, E.C.*3.

Mar. 24, 1914. Brand, Felix R. W.
37, *Hatton Garden, E.C.*1.

Nov. 17, 1905. Bremner, John Unthank
277, *King Street, Hammersmith, W.*6.

Jan. 24, 1911. Bridge, Samuel
28, *Larkhall Rise, Clapham, S.W.*4.

Date of Election.

Nov. 6, 1908. Broad, John Moxon
2, *Nicoll Road, Harlesden, N.W.*10.

June 11, 1918. Brokenshire, Frederick A.
2, *Rock Avenue, Barnstaple.*

Feb. 23, 1915. Brooke, Chas. Hy. Alfred
159, *Sutherland Avenue, W.*9.

Dec. 4, 1908. Brooks, Theodore, F.R.M.S.
Sta Clara Province, Central Caracas, Caracas, Cuba.

Dec. 19, 1890. Brough, J. R.
*"Eversley," Shepherd's Hill, Highgate, N.*6.

Mar. 15, 1907. Browett, William
*"Beaumont," Pearfield Road, Forest Hill, S.E.*23.

May 24, 1910. Brown, Edward George
8, *Freke Road, Battersea, S.W.*11.

Jan. 18, 1907. Brown, Nicholas Edward, A.L.S.
6, *The Avenue, Kew.*

Jan. 28, 1887. Browne, E. T., M.A., F.R.M.S.
Anglefield, Berkhamsted, Herts.

May 14, 1918. Browning, Edgar W. F.
89, *Disraeli Road, Putney, S.W.*15.

May 22, 1917. Browning, Frederick
27, *Cornford Grove, Balham, S.W.*12.

Mar. 18, 1904. Brushfield, N. W.
13, *Allfarthing Lane, Wandsworth Common, S.W.*18.

Jan. 15, 1892. Bryce, David (*Vice-President*)
37, *Brooke Road, Stoke Newington, N* 16.

May 28, 1912. Bull, Albert Edwd.
3, *Canterbury Terrace, Sudbury, Harrow.*

May 15, 1908. Bunting, Percival J.
40, *Pope Street, Belle Vue East, Johannesburg, S.A.*

Jan. 20, 1905. Burnell, Charles Edward
29, *High Street, Shepton Mallet.*

Feb. 28, 1913. Burns, Dr. Nesbitt, M.B., B.A., F.R.S.E.
"The Lodge," Highbridge, Somerset.

Mar. 12, 1918. Burrell, Edward John
11, *Lower Park Loughton, Essex.*

Date of Election.

April 20, 1906. Burrell, T. Leonard
20, *Upper Hornsey Rise, Islington, N.*19.

Jan.. 23, 1917. Burt, Charles Spiller
9, *Fanthorpe Street, Putney, S.W.*

April 28, 1914. Burton-Brown, Gerald Burton, M.D.
112, *Tonbridge Road, Maidstone.*

Feb. 19, 1904. Burton, James (*Hon. Sec.*),
8, *Somali Road, West Hampstead, N.W.*2.

Nov. 28, 1916. Bushell, C. W.
88, *Hawthorn Parade, Haberfield, Sydney, N.S.W.*

May 26, 1914. Buttemer, Robt. Wm., F.C.S., M.I.A.E.
St. Mary's, Godalming.

Feb. 19, 1904. Butterworth, Arthur Cyrus,
Granville, Crowstone Road, Westcliff-on-Sea.

April 15, 1904. Caffyn, Charles Henry
32, *Falkland Road, Hornsey, N.*

June 18, 1897. Campbell, Colney
96, *New River Crescent, Palmers Green, N.*13.

Mar. 16, 1906. Capell, Bruce John, F.R.M.S.
10, *Castelnau, Barnes, S.W.*13.

May 24, 1910. Carruthers, Ferdinand Gilbert
27, *Mosley Street, Newcastle-on-Tyne.*

Jan. 25, 1910. Carter, John Arthur
6, *Temple Road, Stowmarket.*

June 17, 1892. Chaloner, G., F.C.S.
South Street, Colyton, S.O., Devon.

April 24, 1917. Chapple, Wm. Richard
2, *St. George's Avenue, Aldermanbury, E.C.*2.

June 28, 1910. Charlton, Alfred Edward
18, *Bloomsbury Square, W.C.*1.

Oct. 26, 1909. Cheavin, Harold Squire, F.R.M.S.
70, *Somerset Road, Huddersfield.*

April 22, 1913. Cheshire, Frederic John, F.R.M.S.
23, *Carson Road, Dulwich, S.E.*2.

Date of Election.

Mar. 22, 1878. Chester, The Very Rev. the Dean of
The Deanery, Chester.

Dec. 18, 1896. Chipps, F. W.
201, *Castelnau, Barnes, S.W.*13.

Jan. 20, 1905. Christie, John, F.R.M.S.
Henleigh, Kingston Hill, Surrey.

Mar. 17, 1905. Clemence, Walter
14, *Beckenham Grove, Shortlands.*

Jan. 27, 1914. Clibborn, Lt.-Col. John
87, *Victoria Street, S.W.*1.

Oct. 18, 1907. Coldwells, William Henry
Redcote, Shirley Road, Wallington.

June 11, 1918. Collins, William George
Trefriw, Highworth Avenue, Cambridge.

Oct. 21, 1904. Conrady, Alexander Eugen, F.R.A.S.
23, *Flanchford Road, Stamford Brook, W.*12.

Mar. 25, 1913. Cook, John Thomas
216, *Clive Road, West Dulwich, S.E.*21.

April 28, 1914. Cooley-Martin, Francis
"*Hillside,*" *Portsdown, Cosham, Hants.*

Nov. 26, 1912. Coon, Joseph May
"*Morwenna,*" *St. Austell.*

Jan. 18, 1901. Cox, Thomas N.
Hill Cottage, Bencombe Road, Purley.

Jan. 15, 1904. Cox, William
"*The Pound,*" *Lingfield, Surrey.*

Jan. 25, 1910. Crabtree, James Fox, B.A.
40, *Brazennose Street, Manchester.*

April 27, 1915. Craig, Rev. S. Runsie
"*Craigmount,*" *Central Hill, Upper Norwood, S.E.*19.

Nov. 25, 1913. Creese, Edward J. E., F.Z.S., F.R.M.S.
29, *Cornford Grove, Balham, S.W.*12.

Nov. 21, 1902. Cressey, Dr. G. H.
Oak Manor, Tonbridge.

Aug. 28, 1868. Crisp, Sir Frank, LL.B., V.P.L.S., B.A., F.R.M.S., F.G.S., F.Z.S.
5, *Lansdowne Road, Notting Hill, W.*11.

Date of Election.

Nov. 16, 1906. Crosbie, Walter
Kenilworth, Willenhall, New Barnet.

Feb. 16, 1900. Crossland, R. E., A.R.I.B.A.
9, *King's Bench Walk, Temple, E.C.*4.

Mar. 16, 1894. Culshaw, Rev. George H., M.A.
The Rectory, Iver Heath, Bucks.

May 22, 1917. Cunningham, W. T. P.
77, *The Grove, Palmers Green, N.*13.

Jan. 16, 1903. Curties, C. Lees
244, *High Holborn, W.C.*1.

May 18, 1906. Cuzner, Edgar, F.R.M.S.
36, *Trothy Road, Bermondsey, S.E.*1.

Nov. 18, 1904. Dade, Willoughby Dreyer
9, *Bincleaves Road, Weymouth.*

Jan. 17, 1908. Dallas, Charles Caldwell, F.R.G.S., F.Z.S.
Eastley Wootton, New Milton, Hants.

Dec. 21, 1906. Darlaston, Herbert William Hutton
31, *Freer Road, Birchfield, Birmingham.*

Feb. 28, 1911. Davidson, John, B.Sc.
111, *Queen Street, Cardiff.*

June 16, 1905. Davies, Daniel, F.R.M.S.
12, *Eliot Hill, Blackheath, S.E.*3.

June 24, 1913. Dean, Frank
1, *Langham Street, Portland Place, W.*1.

May 17, 1901. Deeley, George P.
Moushall, Amblecote, Brierley Hill, Staffordshire.

April 19, 1895. Delcomyn, Theo. A.,
"*Feldheim,*" *Wimbledon Common, S.W.*19.

Jan. 23, 1912. Dendy, Arthur, D.Sc., F.R.S. (*Vice-President*)
*Vale Lodge, Hampstead Heath, N.W.*3.

Feb. 23, 1915. Denne, M. T.
Henley House, Upper Warlingham, Surrey.

Mar. 22, 1889. Dick, J.
*Milber, Victoria Road, Mill Hill, N.W.*7.

Feb. 15, 1907. Dilks, Arthur Charles, B.Sc.
Tardebigge, Bromsgrove.

Date of Election.

June 17, 1892. Dixon-Nuttall, F. R., F.R.M.S.
"*Ingleholme,*" *Eccleston Park, near Prescot, Lancashire.*

Nov. 25, 1913. Dobell, Henry
74, *Babbacombe Road, Bromley, Kent.*

Oct. 24, 1911. Downing, Owen Walter
23, *Glenhouse Road, Eltham, S.E.*9.

Mar. 17, 1899. Downs, Arthur
2, *Ulverston Road, Walthamstow, E.*17.

Nov. 23, 1915. Drake, Arthur Penrhyn, A.M.I.E.E.
51, *The Chase, Nottingham.*

Nov. 23, 1909. Draper, Bernard M.
9, *Pitt Street, Kensington, W.*8.

Nov. 15, 1901. Druett, C. R.
330, *Uxbridge Road, W.*12.

Jan. 8, 1918. Duncan, Francis Martin
71, *St. Leonards Road, East Sheen, S.W.*14.

April 27, 1915. Duncanson, John Richard
41, *Atholl Mansions, S. Lambeth Road, S.W.*8.

Feb. 25, 1913. Durrad, John Wm., F.R.A.S.
350, *Fosse Road North, Leicester.*

June 19, 1891. Earland, Arthur, F.R.M.S.
34, *Granville Road, Watford.*

June 26, 1917. Edgar, Joseph
8, *Newman Street, W.*1.

April 22, 1913. Edwards, Henry
22, *St. Bartholomew's Road, Reading.*

Oct. 22, 1912. Edwardes, Seabury
Bhamo, Upper Burma.

Feb. 21, 1902. Edwards, Thomas Jarvis
9, *St. Lawrence Road, Brixton, S.W.*2.

Oct. 22, 1912. Elliott, Wm.
97, *Devonport Road, Shepherd's Bush, W.*12.

Mar. 22, 1910. Ellis, William Neale
The "Pharmacy," Appledore, Devon.

Nov. 28, 1911. Emsley, Harold Percy
31, *Victoria Road, Wood Green, N.*22.

Date of Election.

Mar. 24, 1914. Engleheart, Conrad Wm.
6, Shaftesbury Villas, Kensington, W.8.

Nov. 17, 1905. Evans, Morris B.
"Springwell," Hayes End Road, Middlesex.

June 26, 1917. Evans, John Goodbart
Kelleythorpe Park Road, Hale, Cheshire.

April 27, 1915. Evans, Roy Gerald
9, Chertsey Road, Redland, Bristol.

Mar. 12, 1918. Evens, Eric Doddrell
8, Christchurch Road, Hampstead, N.W.3.

Dec. 21, 1906. Fawcett, Henry Hargreave
Thorncombe, near Chard, Somerset.

June 24, 1913. Fendick, Ernest Alfred
22, Finedon Road, Wellingborough, Northants.

June 16, 1893. Filer, Frank E.
Glyn House, Ewell, Surrey.

Feb. 19, 1904. Finlayson, Daniel
"Redfern," Pellatt Grove, Wood Green, N.22.

Feb. 24, 1914. Finlayson, Raymond
22, Pellatt Grove, Wood Green, N.22.

Nov. 28, 1916. Fletcher, Joseph, B.D., B.A.
17, Fairfield Road, Croydon.

Nov. 23, 1888. Flood, W. C.
119, Highbury Hill, N.5.

Jan. 23, 1917. Flower, John William, A.M.I.E.E.
"Woodside," The Avenue, Muswell Hill, N.6.

Mar. 25, 1913. Ford-Fone, W. Edwin
146, Palmers Road, New Southgate, N.11.

April 9, 1918. Fox, Alfred Harry Matthews
96, Lewin Road, Streatham, S.W.16.

June 23, 1871. Freeman, Henry Edward
69, Limes Avenue, New Southgate, N.11.

Dec. 16, 1898. French, Archibald J.
57, Ermine Road, Lewisham, S.E.13.

Date of Election.

Jan. 18, 1907. Fuelling, George Ernest
195, *High Road, Streatham, S.W.*16.

Feb. 22, 1910. Fuller, Frederick Charles
7, *Goldington Road, Bedford.*

May 15, 1903. Gabb, G. H., F.C.S.
83, *Crayford Road, Tufnell Park, N.*7.

Nov. 28, 1916. Gadsden, J.
"*Ferndale,*" *Kew, Melbourne.*

Nov. 25, 1913. Gamman, Robt.
13, *Park Road, High Barnet.*

Dec. 15, 1905. Gardner, Edward Lewis
1, *Craven Road, Harlesden, N.W.*10.

Jan. 20, 1899. Gardner, William, F.R.M.S.
292, *Holloway Road, N.*7.

Dec. 16, 1904. Garnett, Theodore, M.A. Oxon
South Bank, Grassendale, Liverpool.

Jan. 27, 1914. Gee, Harry Arthur

May 23, 1916. George, Alfred
"*Clovelly,*" Beresford Road, Harrow, *Middlesex.*

Mar. 28, 1916. Gillies, David
3, *Hurst Road, Bexley, Kent.*

Mar. 24, 1914. Gingell, Leonard Ralph
111B, *High Street, Hastings.*

Mar. 22, 1910. Gonville, Cyril H. K.
"*Roslin,*" *Queen's Road, Buckhurst Hill, N.*

Feb. 24, 1914. Gooding, Alfred Charles
53, *Park Road, Battersea, S.W.*11.

Dec. 28, 1909. Gooding, Henry Cornish
Stowmarket, Suffolk.

Feb. 12, 1918. Goodman, Alexander
137, *Adelaide Road, Primrose Hill, N.W.*3.

April 2, 1909. Gordon, Fred Wm., F.R.M.S.
"*Graylands,*" *Augustus Road, Wimbledon Park, S.W.*19.

Feb. 22, 1910. Gordon, John W.
113, *Broadhurst Gardens, Hampstead, N.W.*6.

Date of Election.

Jan. 25, 1910. Green, Frederick W.
42, *Roxboro' Park, Harrow.*

June 11, 1918. Green, Henry Frederick
20, *Denbigh Road, West Ealing, W.13.*

Jan. 16, 1903. Green, H. O.
4, *Leamington Gardens, Seven Kings.*

May 24, 1910. Grundy, James, F.R.M.S.
"*Ruislip,*" *Teignmouth Road, Cricklewood, N.W.2.*

June 25, 1912. Gurney, Joseph
Downs Farm, Pinner S.O., Middlesex.

Nov. 28, 1911. Guye, Dr. Paul
12, *Rue de Candolle, Geneva, Switzerland.*

Nov. 24, 1914. Hamilton, Geo. Clarendon

Feb. 22, 1910. Hammond, Alfred Gauntlett
101, *Melody Road, Wandsworth, S.W.18.*

Oct. 22, 1886. Hampton, W.
The Manor House, Weston, Staffordshire.

Mar. 28, 1916. Hardcastle, Alfred
179, *Felsham Road, Putney, S.W.15.*

May 19, 1905. Harris, Charles Poulet, M.D., M.R.C.S., L.R.C.P., F.R.M.S.
192, *Lower Addiscombe Road, Croydon.*

Jan. 27, 1914. Harris, Leslie Edwin
19, *Cheriton Square, Balham, S.W.17.*

May 25, 1915. Hartley, Walter E. T.
5, *Pitt Terrace, Stirling, N.B.*

Dec. 21, 1906. Hasslacher, Charles John
3, *Kensington Park Gardens, W.11.*

Mar. 28, 1879. Hawkins, C. E.
23, *Dalebury Road, Upper Tooting, S.W.17.*

June 13, 1914. Hawksley, Chas. Worthington
115, *Fellowes Road, S. Hampstead,* N.W 3.

Feb. 15, 1901. Headley, F. W.
Haileybury College, Hertford.

May 22, 1917 Hearson, Charles E.
5, *Templar Street, Camberwell, S.E.5.*

Date of Election.

Jan. 19, 1906. Heath, Charles Emanuel, F.R.M.S.
178, Loughboro' Road, Brixton, S.W.9.

Nov. 28, 1916. Hensman, Leonard Newton
2, Killarney Road, Wandsworth, S.W.18.

April 20, 1906. Herbert, Robert Henry
74, Welldon Crescent, Harrow.

Feb. 21, 1908. Heron-Allen, Edward, F.L.S., F.G.S., F.R.M.S., F.R.Met.S., F.Z.S.
33, Hamilton Terrace, N.W.8, and Large Acres, Selsey Bill, Sussex.

Dec. 20, 1901. Hicks, Frederick H.
8, Belmont Road, Wallington, Surrey.

Dec. 22, 1910. Higginson, George Neale

Dec. 11, 1917. Hight, Edward
Cleve Hall, Champion Hill, S.E.5.

Nov. 28, 1916. Hill, Arthur Stanley
Royal Colonial Institute, Northumberland Avenue, W.C.2.

May 23, 1916. Hill, Cyril F.
Druids Croft, Kinnaird Avenue, Bromley, Kent.

Nov. 26, 1912. Hill, Wm., F.G.S.
"The Maples," Hitchin.

Nov. 15, 1895. Hilton, A. E.
1, Highwood Avenue, North Finchley, N.12.

Jan. 8, 1918. Hirst, Stanley
British Museum (Natural History), Cromwell Road, S.W.7.

May 15, 1908. Hiscott, Thomas Henry, F.R.M.S.
16, Woodville Road, Ealing, W.5.

May 27, 1913. Hoare, Stanley
71, Avenue Road, Regent's Park, N.W.1.

Dec. 15, 1893. Holder, J. T.
114, Pepys Road, New Cross, S.E.14.

May 14, 1918. Hollis, George Thomas
41, Sussex Street, E. 14.

Dec. 20, 1907. Holmes, Frederick
217, Franciscan Road, Tooting, S.W.17.

June 25, 1912. Hook, Gerald Francis
97, Mortlake Road, Kew Gardens.

Date of Election.	
May 27, 1913.	Hook, Reginald Vincent 9, *Barrowgate Road, Chiswick, W.4.*
Jan. 15, 1904.	Hopkinson, John, F.L.S., F.G.S., F.R.M.S. *Weetwood, Watford.*
April 15, 1898.	Hounsome, John 21, *Edith Road, Plashet Grove, East Ham, E.6.*
Dec. 4, 1908.	Howard, George *Sitwell Vale, Moorgate, Rotherham, Yorks.*
Oct. 19, 1894.	Howard, R. N., M.R.C.S., F.R.M.S. *The Cape Copper Co., Ookiep, Port Nolloth, Namaqualand, Cape Colony, South Africa.*
Oct. 19, 1894.	Hughes, F. *Wallfield, Reigate.*
Nov. 23, 1909.	Huish, Charles Henry, F.R.M.S. "*The Limes,*" *London Road, Redhill.*
June 4, 1909.	Hunter, John E. "*Strathblane,*" *Park Road, Wallington.*
Dec. 20, 1901.	Hurrell, Harry Edward 25, *Regent Street, Great Yarmouth.*
Feb. 25, 1913.	Hutchin, Chas. Duncan *c/o Meredith & Drew, Ltd., High Street, Shadwell, E.1.*
May 24, 1867.	Ingpen, J. E., F.R.M.S. 21, *Wrotham Road, Broadstairs.*
Feb. 16, 1906.	Inwards, Richard, F.R.A.S. 6, *Croftdown Road, Highgate Road, N.W.5.*
Feb. 22, 1916.	Jackson, James Joseph 30, *Windsor Road, Wanstead, E.7.*
Feb. 28, 1911.	Jacob, Hugh Frederick Dawson, M.I.E.E. B5, *Clive Buildings, Calcutta.*
April 26, 1910.	Jervis, Rev. Edward S. *St. Peter's Vicarage, Streatham, S.W.16.*
Nov. 24, 1914.	Jewell, Harry 23, *Beaty Avenue, Toronto, Canada.*
Nov. 22, 1910.	Jewell, Henry 152, *Leathwaite Road, Clapham Common, S.W.11.*

Date of Election.

Feb. 27, 1917. John, Ambrose Hilton, M.B.B.S. Lond.
6, *Brook Street, Stoke-on-Trent.*

Nov. 17, 1905. Jones, Arthur Morley
24, *Grove Avenue, Hanwell, W.*7.

April 26, 1910. Jones, George Fisher
Devonshire House, Osterley Park Road, Southall, W.

Jan. 18, 1907. Jones, Rev. Robert Francis
28, *Douglas Road, Canonbury, N.*1.

Feb. 22, 1910. Jones, William Llewellyn
Manley Knoll, Helsby, Cheshire.

Feb. 22, 1910. Joshua, Edward Cecil
St. James's Buildings, William Street, Melbourne, Victoria.

Nov. 17, 1905. Karleese, Benjamin
The Dell, Barnt Green, Worcestershire.

May 23, 1873. Karop, G. C., M.R.C.S., F.R.M.S., etc.
Inniscorig, Beltinge Road, Herne Bay.

Feb. 25, 1913. Kaufmann, James C., LL.D.
49, *Queen Street, Melbourne.*

June 21, 1907. Kemp, Francis H. N. C.
15, *Vernon Road, Hornsey, N.*8.

July 25, 1884. Kern, J. J.
63, *Queens Road, Beckenham, Kent.*

Nov. 18, 1904. Kew, H. Wallis
3, *Herndon Road, Wandsworth, S.W.*18.

Jan. 23, 1917. Kiell, John
19, *Stapleton Road, Upper Tooting, S.W.*17.

June 23, 1914. King, Chas. Jas. Reeves
64, *Shell Road, Lewisham, S.E.*13.

Nov. 23, 1915. King, Geo. W.
163, *Boro' High Street, S.E.*1.

May 17, 1901. Kirkman, Hon. Thomas, M.L.C., F.R.M.S.
Croftlands, Esperanza, Natal.

May 19, 1905. Kitchin, Joseph, F.R.M.S.
"*Ingleneuk,*" 14, *Brackley Road, Beckenham, Kent.*

Mar. 22, 1889. Klein, S. T., F.R.A.S., F.L.S.
"*Hatherlow,*" *Raglan Road, Reigate.*

Date of Election.	
Oct. 28, 1913.	Knox Stuart, G. E. Inman
Dec. 28, 1909.	Knox, Sydney W. 61, *Cambridge Street, Hyde Park, W.2.*
Feb. 17, 1905.	Lambert, Charles Alexander *c/o Bank of New South Wales, Melbourne, Victoria.*
Jan. 18, 1907.	Larkin, Thomas Gaisford 29, *Thornlaw Road, W. Norwood, S.E.27.*
April 27, 1915.	Lauwers, Walter 51, *Temple Fortune Hill, Hampstead Garden Suburb, N.W.4.*
June 17, 1904.	Lawrence, Frederick George *c/o Lionel Samson & Son, Cliff Street, Fremantle, West Australia.*
Feb. 25, 1913.	Lawrence, Harry John 7, *Norman Road, South Wimbledon, S.W.19.*
April 26, 1910.	Lawrence, William John 21, *Cambridge Road, Lee, S.E.3.*
Mar. 16, 1900.	Lawson, Peter 13, *Nella Road, Fulham Palace Road, S.W.6.*
Nov. 13, 1917.	Lawson, Stuart 30, *Marlborough Road, Chiswick, W.4.*
Jan. 20, 1905.	Lees, Rev. Frederick Clare, 45, *Cavendish Road, Sutton, Surrey.*
May 23, 1916.	Leeson, John Rudd, M.D., F.L.S., F.R.M.S. *Clifden House, Heath Road, Twickenham.*
Nov. 21, 1902.	Leonard, Edward 14, *Fairview Road, Oxton, Birkenhead.*
Feb. 22, 1910.	Lewis, Frederic Henry "*Ashmore,*" *King's Avenue, Clapham Park, S.W.4.*
Nov. 25, 1913.	Liddon, Capt. Matthew Robert 2, *Westwood Road, Southampton.*
June 26, 1917.	Lindwall, Stanley 45, *Madrid Road, Barnes, S.W.13.*
Mar. 24, 1914.	Lloyd, Francis Wm. 85, *Gracechurch Street, E.C.3.*

Date of Election.

June 11, 1918. Lock, Charles J.
R.M.S., 20, Hanover Square, W.1.

Dec. 23, 1913. Lock, Thos. Benjn.
78, *Riggindale Road, Streatham, S.W.16.*

Mar. 23, 1915. Longmire, J.
23, *Furnival Street, E.C.4.*

Oct. 27, 1914. Loxton, Samuel E., F.R.A.S.
"Icknield," Little Aston, nr. Sutton Coldfield.

May 25, 1883. Mainland, G. E., F.R.M.S.
14, *The Norton, Tenby, South Wales.*

June 27, 1916. Maitland, Ernest Augustus
96, *Nibthwaite Road, Wealdstone, Harrow.*

Nov. 24, 1914. McTavish, Alex.
Cowley Grove Cottage, Uxbridge.

May 23, 1916. McEwen, Alfred
1118, *Marbridge Building, Herald Square, New York, U.S.A.*

Nov. 26, 1912. Mardon, Daniel Arthur
Avon Cottage, Grange Road, Bishops Stortford.

Jan. 24, 1911. Marsh, George Robertson, M.A.
Mallards Close, Twyford, near Winchester, Hants.

Feb. 15, 1895. Marshall, William John, F.R.M.S.
15, *Elms Road, Dulwich Village, S.E.21.*

Nov. 28, 1916. Martin, John
The Laurels, 60, *Culverdon Road, Balham, S.W.12.*

May 18, 1906. Martin, William
"Kethlen," Burgh Heath, Epsom, Surrey.

Jan. 15, 1892. Maw, W. H., F.R.M.S., F.R.A.S.
18, *Addison Road, Kensington, W.14.*

Mar. 28, 1911. Maxwell, Edward Kelly, B.A.
H.M. Patent Office, W.C.2.

May 19, 1893. Merlin, A. A. C. Eliot, F.R.M.S.
British Consulate, Volo, Greece.

May 22, 1917. Melhuish, F.
Nat. Debt Office, 32, *London Wall, E.C.2.*

Date of Election.

July 27, 1877.	Michael, A. D., F.L.S., F.Z.S., F.R.M.S. *The Warren, Studland, near Swanage, Dorset.*
Feb. 25, 1913.	Mills, Fdk. Wm., F.R.M.S. *Thornleigh Edgerton, Huddersfield.*
Jan. 20, 1905.	Milne, William 70, *Beech Grove Terrace, Aberdeen.*
Oct. 18, 1901.	Moore, Harry, F.R.M.S. 12, *Whiston Grove, Moorgate, Rotherham, Yorks.*
July 26, 1878.	Morland, Henry *Cranford, near Hounslow.*
June 4, 1909.	Mortimer, Hugh Hamilton 15, *Mulgrave Road, Croydon.*
Jan. 16, 1891.	Muiron, C. 49, *Chatsworth Road, Brondesbury, N.W.*2.
Nov. 22, 1910.	Mummery, J. Howard, M.R.C.S. 79, *Albert Bridge Road, Battersea, S.W.*11.
June 16, 1905.	Myles, James Cellars 53, *Carlyle Road, Manor Park, E.*12.
Jan. 27, 1914.	Nall, Rev. Geo. Herbert, M.A., F.R.M.S. 18, *Deans Yard, Westminster, S.W.*1.
Mar. 24, 1876.	Nelson, E. M., F.R.M.S. *Beckington, Bath.*
Feb. 15, 1907.	Newman, Charles Arnold *Oundle, Northants.*
May 27, 1913.	Newmarch, Edgar Ribton 4, *The Drive, Walthamstow, E.*17.
Jan. 26, 1872.	Newton, E. T., F.R.S., F.G.S. *Florence House,* 13, *Willow Bridge Road, Canonbury, N.*1.
Feb. 12, 1918.	Niblett, Arthur Henry *Springfield House, Keresley, nr. Coventry.*
Jan. 17, 1908.	Nicholson, Alfred 19, *Victoria Road, Salisbury.*
Nov. 28, 1916.	Nicholson, Charles *Lansdowne House, Morley Street, Bradford.*

Date of Election.	
June 23, 1914.	Norman, Geoffrey 8, *Cliffords Inn, E.C.*4.
Nov. 28, 1911.	Nutt, Hy. Francis 51, *Gurdon Road, Charlton, S.E.*7.
Feb. 25, 1913.	Oatley, Wm. *Badcox, Frome*
Feb. 16, 1900.	O'Donohoe, T. A. 8, *Myrtle Road, Acton, W.*3.
Jan. 24, 1879.	Offord, J. M., F.R.M.S. 3, *Cleveland Gardens, West Ealing, W.*5.
Dec. 22, 1876.	Ogilvy, C. P., F.L.S. *Sizewell House, Leiston, near Saxmundham, Suffolk.*
May 17, 1907.	Ogilvy, J. Wilson, F.R.M.S. 18, *Bloomsbury Square, W.C.*1.
Nov. 15, 1907.	Oke, Alfred William, B.A., LL.M. 32, *Denmark Villas, Hove.*
June 11, 1918.	Oram, Ashley Edward 23, *Goldhurst Terrace, S. Hampstead, N.W.*6.
Nov. 18, 1892.	Orfeur, Frank, F.R.M.S. 78, *Avondale Road, South Croydon.*
Dec. 27, 1867.	Oxley, Frederick, F.R.M.S. *c/o A. E. Linton, Esq., Box* 9, *P.O., Nairobi, British East Africa.*
Dec. 18, 1903.	Oxley, F. J., M.R.C.S. 1, *Dock Street, E.*1.
Feb. 27, 1912.	Palmer, Hy., J.P., F.R.G.S. 1, *Pelaw Terrace, Durham.*
Nov. 25, 1913.	Panichelli, Frank 7, *Rowan Road, Hammersmith, W.*6.
April 10, 1910.	Parfitt, Edward William 7, *Gatcombe Road, Tufnell Park, N.*19.
Feb. 25, 1913.	Parrott, Fdk. Wm. "*Morningside,*" *Albert Road, Hale, Cheshire.*
Oct. 27, 1871.	Parsons, F. A., F.R.M.S. 15, *Osborne Road, Stroud Green, N.*

Date of Election.	
Dec. 16, 1904.	Patterson, George 20, *Madrid Road, Castlenau, Barnes, S.W.*13.
Jan. 18, 1901.	Paulson, Robert, F.L.S., F.R.M.S. *"Glenroy," Cecil Park, Pinner, Middlesex.*
Oct 24. 1916.	Penn, Charles Walter 80, *Burbage Road, Herne Hill, S.E.*24.
May 20, 1904.	Perks, Frederick John (*Hon. Treasurer*). 48, *Grove Park, Denmark Hill, S.E.*5.
Jan. 18, 1907.	Perry, Francis Gough 2, *The Cloisters, Gordon Square, W.C.*1.
Dec. 11, 1917.	Pike, Evan Vaughan 13, *Mayola Road, Clapton, E.*5.
Nov. 15, 1895.	Pillischer, J., F.R.M.S. 88, *New Bond Street, W.*1.
April 25, 1910.	Pinchin, Ernest Alfred, B.Sc. 4, *Gleneldon Road, Streatham, S.W.*16.
Jan. 15, 1904.	Pledge, John H., F.R.M.S. 72, *Nibthwaite Road, Harrow.*
Nov. 23, 1883.	Plowman, T. *Nystuen Lodge, Bycullah Park, Enfield.*
Sept. 21, 1894.	Pollard, Jonathan, F.R.M.S. 10, *Porteus Road, Paddington Green, W.*2.
June 21, 1895.	Poulter, Christopher S. *Mount Lodge, Parkhurst Road, Bexley, Kent.*
May 17, 1901.	Powell, David, M.A., F.R.M.S. *Overstrand, Grove Park Road, Chiswick, W.*4.
Dec. 20, 1907.	Pratt, John Edwin 6, *Heathfield Terrace, Seven Kings, Essex.*
June 22, 1915.	Price, Reginald A. 11*a*, *Holland Road, Brixton, S.W.*9.
Nov. 26, 1912.	Pulford, Herbert, M.A., etc. *Broom Hill, Limpsfield, Surrey.*
Nov. 6, 1908.	Quick, Albert Hedley *"Inverness," Malvern Road, Thornton Heath.*

Date of Election.

Jan. 18, 1901. Radley, Percy E., F.R.M.S.
Nesta, Broxbourne, Herts.

Nov. 25, 1913. Ramsay, Ernest Wm., P.A.S.I.
16, *Whiteley Road, Upper Norwood, S.E.*19.

Mar. 28. 1916. Rasquin, Georges
46, *Cunningham Park, Harrow-on-the-Hill.*

Feb. 27, 1917. Read, Rev. Thomas
*S. John's College, Battersea, S.W.*11.

Feb. 27, 1917. Rendel, Alfred Barton, D.Sc., F.R.S. (*President*)
*British Museum (Natural History), Cromwell Road, S.W.*7.

Mar. 20, 1896. Rheinberg, Julius, F.R.M.S.
23, *The Avenue, Brondesbury Park, N.W.*2.

Mar. 23, 1915. Ribbons, Joseph Lovelace
"*Greenhill,*" *Reynolds Road, Beaconsfield.*

Sept. 18, 1891. Richards, F. W.
104, *St. Luke Street, Montreal, Canada.*

Oct. 2, 1908. Richards, William
"*Poulters,*" *Bentley, Hants.*

Jan. 18, 1901. Richardson, John
28, *Beaumont Avenue, Richmond, Surrey.*

June 21, 1901. Robertson, Sir Helenus R., F.R.M.S.
Upton Grange, Chester.

Mar. 15, 1907. Robertson, James Alexander, F.R.M.S.
Sunnyside, Fleetwood.

Mar. 12, 1918. Robertson, W. J.
69, *Bedford Road, Clapham, S.W.*4.

April 28, 1914. Robotham, Fras. Edward
48, *Lillieshall Road, Clapham, S.W.*4.

May 23, 1916. Robins, Edmund Arthur
Swinton Lodge, Essex Road, Watford.

Nov. 13, 1917. Rodman, George Hook, M.D., F.R.P.S.
4, *Heath Mansions, Putney Heath, S.W.*15.

June 4, 1909. Rolph, Frank
50, *Ingatestone Rd., Woodford Green, E.*18.

Jan. 26, 1883. Rousselet, Charles F. (*Vice-President and Hon. Secretary for Foreign Correspondence*), Curator R.M.S.
4, *St. Matthew's Drive, S. Leonards-on-Sea.*

Date of Election.

Nov. 26, 1912. Row, Rd. Wm. Harold
36, Lexham Gardens, Kensington, W.8.

Nov. 18, 1904. Rowley, Frederick Richard, F.R.M.S.
8, Pinhoe Road, Heavitree, Exeter.

April 27, 1888. Russell, J.
16, Blacket Place, Newington, Edinburgh.

Mar. 24, 1914. St. George, Harry A.
112, Albany Street, Regent's Park, N.W.1.

April 2, 1909. Saxton, Thomas R., A.M.I.C.E., F.R.M.S.
43, East Bank, Stamford Hill, N.16.

June 20, 1890. Scourfield, D. J., F.Z.S., F.R.M.S. (*Vice-President*)
63, Queen's Road, Leytonstone, E.17.

May 20, 1898. Sears, Robert S. W.
1, Lisson Grove, N.W.1.

Nov. 25, 1913. Shepherd, Benjamin
Fir Cottage, Oak Lane, Bounds Green, N.11.

Dec. 28, 1909. Shephard, John
Clark Street, South Melbourne, Victoria.

June 21, 1907. Sheppard, Alfred William, F.R.M.S. (*Hon. Editor*)
1, Vernon Chambers, W.C.1.

Jan. 28, 1913. Sheppard, Edwd. Jas., F.R.M.S.
137, Kennington Road, S.E.11.

Mar. 25, 1913. Shuckard, David Hy.
14, Walerand Road, Lewisham, S.E.13.

Feb. 28, 1911. Sidebottom, Henry
"Woodstock," Syddal Park, Bramhall, Cheshire.

June 19, 1896. Sidwell, Clarence J. H., F.R.M.S. (*Hon. Curator*)
46, Ashbourne Grove, Dulwich, S.E.22.

Feb. 22, 1910. Simpson, Norman Douglas
Carlton Lodge, 8, Wellington Road, Bournemouth.

Oct. 21, 1904. Smith, Arthur Edgar
"Helios," 71, Fox Lane, Palmer's Green, N.13.

Date of Election.

April 24, 1917. Smith, Charles Howard
59, Nelson Road, Stroud Green, N.

Mar. 25, 1870. Smith, F. L.
49, *Belvedere Road, Upper Norwood, S.E.*19.

Mar. 17, 1899. Smith, Frank P.
2, *King's Villas, Chase Road, Southgate. N.*14.

Mar. 17, 1905. Smith, Frederick
13, *Rye Hill Park, Peckham Rye, S.E.*15.

Mar. 28, 1916. Smith, Herbert Havet
6, *Preston Road, Westcliff-on-Sea.*

Nov. 18, 1898. Smith, Thomas J., F.R.M.S.
c/o W. Watson & Sons, 313, *High Holborn, W.C.*1.

Jan. 15, 1892. Soar, C. D., F.L.S., F.R.M.S.
37, *Dryburgh Road, Putney, S.W.*15.

Feb. 23, 1915. Sollis, Wm. Powell

April 24, 1917. Sonntag, Charles Frederick
126, *Great Portland Street, W.*1.

April 21, 1899. Spitta, Edmund J., L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S.
41, *Ventnor Villas, Hove, Brighton.*

Jan. 15, 1904. Sprague, T. B., LL.D.
West Holme, Woldingham, Surrey.

Jan. 28, 1913. Spry, Lt. Robt., R.N., F.R.M.S.
83, *Mount Gold Road, Plymouth.*

Jan. 18, 1907. Stahl, Arthur
11, *Scotts Avenue, Shortlands, Kent.*

Jan. 25, 1916. Stephanides, Theodore

Nov. 27, 1885. Stevenson, G. T.
Ravenscourt, Haling Park Road, South Croydon.

June 18, 1897. Still, Arthur L.
Roslyn, Dower Avenue, Wallington.

Nov. 16, 1894. Stokes, William B.
212, *Notre Dame Street, West Montreal.*

Jan. 23, 1917. Stow, Albert Archie
The Croft, New Malden, Surrey.

Date of Election.

Oct. 24, 1916. Stringer, Edward Belcher
Egerton Lodge, Bromley, Kent.

Dec. 15, 1893. Sturt, Gerald
"Lismore," Cavendish Road, Weybridge.

Dec. 17, 1875. Swift, M. J., F.R.M.S.
6, *Aylestone Avenue, Brondesbury, N.W.*6.

Dec. 28, 1915. Syer, John
Stanmore Hill, Middlesex.

Nov. 28, 1879. Tasker, J. G.
30, *Junction Road, Upper Holloway, N.*19.

Oct. 16, 1896. Taverner, Henry, F.R.M.S.
319, *Seven Sisters Road, Finsbury Park, N.*4.

Feb. 17, 1905. Taylor, Thomas George
Ballaclague, Ellington Park Road, Ramsgate.

Mar. 28, 1916. Tennant, John, M.A.
19, *The Boltons, S.W.*10.

Mar. 28, 1916. Terry, Henry Clarke
"Collingwood," Kenwyn Street, Harstville, N.S.W.

Dec. 22, 1865. Terry, John
8, *Hopton Road, Streatham, S.W.*16.

Feb. 12, 1918. Thomas, Benjamin John
70, *Belleville Road, Wandsworth Common, S.W.*11.

Mar. 28, 1916. Thomas, Reginald Walter
15, *Ambrose Avenue, Golders Green, N.W.*4

June 26, 1917. Thomas, Robert Herbert
174, *St. Leonards Road, East Sheen, S.W.*14.

June 24, 1913. Tierney, Clarence M. S., B.Sc., F.R.M.S.
"Netherton," Coulsdon, Surrey.

May 16, 1902. Tilling, George, F.R.M.S.
*"Grasmere," Rydal Road, Streatham, S.W.*16.

Nov. 25, 1913. Tilling, Wm. Geo.
20, *Streathbourne Road, Upper Tooting, S.W.*17.

Date of Election.

Nov. 24, 1914. Tindall, Wm. B.
39, St. Mary Street, Toronto, Canada.

April 9, 1918. Tipping, William Moore
Bryn Pabo, near Llandudno.

June 11, 1918. Titchener, George Richard
10, *Dalberg Road, Brixton, S.W.*2.

Jan. 25, 1910. Todd, Charles Stephen
25, *Hanover Road, Tottenham, N.*17.

Feb. 27, 1912. Tomlinson, Edwd. Theodore
8, *St. George's Square, S.W.*1.

April 25, 1916. Topsent, Prof. Emile
Faculté des Sciences Dijon (Cote d'or), France.

Dec. 21, 1894. Traviss, Will. R.
42, *Winchester Avenue, Brondesbury, N.W.*6.

Nov. 13, 1917. Trist, Arthur Ronald
"Birchfield," Aldenham Road, Bushey.

Feb. 25, 1913. Trotman, Alex. Chas.
28, *Gubyon Avenue, Herne Hill, S.E.*24.

Mar. 5, 1909. Troughton, Henry George
3, *New Court, Lincoln's Inn, W.C.*2.

June 17, 1892. Turner, C.
20, *Minster Road, Cricklewood, N.W.*2.

May 25, 1915. Tutt, John Francis Donald, F.R.C.V.S.
"Rothiemurchus," St. Cross, Winchester.

Feb. 25, 1913. Tyas, Rev. Vetranio
12, *Felstead Road, Wanstead, E.*11.

April 9, 1918. Vickery, Ernest James
33, *High Street, Budleigh Salterton, Devon.*

July 25, 1873. Walker, J. S.
6, *Warwick Road, Upper Clapton, E.*5.

June 26, 1917. Waller, William Thomas
Bingham House, Richmond, Surrey.

Mar. 27, 1917. Wallis, Thomas Edward
5, *Hillsborough Avenue, Exeter.*

Nov. 22, 1910. Watts, Geo. W.
103, *Haverstock Hill, N.W.*3.

Date of Election.

Mar. 20, 1908. West, Joshua Cobbett
"Holly Cottage," Church Street, Sunbury-on-Thames.

Feb. 25, 1876. Wheeler, George

Jan. 25, 1910. Whitehead, Henry, B.Sc. Lond.
23, *Downie Terrace, Murrayfield, Edinburgh.*

Nov. 26, 1912. Whitteron, Fred.
Toorak Avenue, Kooyong, nr. Melbourne, Victoria.

Dec. 4, 1908. Wilkins, Thomas Smith
Eversley, Uttoxeter.

Nov. 23, 1877. Williams, G. S.
Tor Hill, Kingskerswell, Devon.

June 26, 1917. Williams, Henry
21, *Disraeli Road, Putney, S.W.*15.

April 27, 1915. Williamson, Wm.
79, *Morningside Drive, Edinburgh.*

Jan. 19, 1906. Wilson, Joseph, F.R.M.S.
3, *West Park Road, Kew Gardens, S.W.*

Jan. 23, 1917. Winter, Ronald
7, *Homer House, Rushcroft Road, Brixton, S.W.*2.

Feb. 27, 1912. Wood, Fredk. Geo.
161, *Walworth Road, S.E.*17.

June 27, 1916. Wood, Henry, F.C.S.
62, *Culverden Road, Balham, S.W.*12.

Dec. 20, 1895. Wood, Walter J., F.R.M.S.
"Ernecroft," Abbey Road, Grimsby.

Nov. 16, 1894. Wooderson, Edwin
39, *Dartmouth Road, Brondesbury, N.W.*2.

Feb. 27, 1917. Woodman, Frederick William
27, *Park Hill, Clapham, S.W.*4.

Nov. 13, 1917. Woodman, Robert Guthrie
"Churchfield," Halfway, near Sheffield.

Mar. 15, 1907. Worssam, Cecil
17, *Grafton Road, Bedford.*

Jan. 18, 1907. Wright, Joseph Pepper
c/o Messrs. Davidson, Boules, Ld., 86, *Wellington Street, W. Toronto, Canada.*

Jan. 18, 1901. Wykes, William
7, *Plaistow Park Road, Plaistow, Essex, E*.13.

Mar. 24, 1914. Yermoloff, His Excellency Sir Nicolas, K.C.B., K.C.V.O.
3, *Whitehall Court, S.W*.1.

Nov. 23, 1888. Young, G. W., F.G.S.
20, *Grange Road, Barnes, S.W*.13.

NOTICE.

Members are requested to give early information to the Treasurer of any change of residence, so as to prevent miscarriage of Journals and Circulars.

List of Exchanges and of Societies, etc., which Receive the Journal.

American Microscopical Society, T. W. Galloway, Secretary, Beloit College, Beloit, Wisconsin, U.S.A.

Bergens Museums Bibliothek, Bergen, Norway.

Birkbeck College, Bream's Buildings, Chancery Lane, E.C.4.

Birmingham Natural History and Philosophical Society, 55, Newhall Street, Birmingham.

Botanical Society of Edinburgh (The Curator), The Botanic Gardens, Edinburgh.

Botanisches Centralblatt, c/o Dr. J. P. Lotsy, Spaarne 17, Haarlem, Holland.

Brighton and Hove Natural History Society, c/o The Public Library, Brighton.

Bristol Naturalists' Society (The Librarian), 5, Lansdown Place, Clifton, Bristol.

British Association for the Advancement of Science, Burlington House, London, W.1.

Canadian Institute, W. H. Vandersmitten, Esq., Secretary, 46, Richmond Street East, Toronto, Canada.

Concilium Bibliographicum, Zürich, Neumünster, Switzerland.

Croydon Natural History and Scientific Society (The Secretary), Public Hall, Croydon.

Dohrn, Prof. Reinhart, The Zoological Station, Naples.

"English Mechanic," 5, Effingham House, Arundel Street, W.C.2.

Entomological Society, 11, Chandos Street, Cavendish Square, W.1.

Essex Field Club, Essex Museum of Natural History, Stratford, E.15.

Geologists' Association (The Librarian), University College, Gower Street, W.C.1.

Herts Natural History Society, c/o Daniel Hill, Esq., "Herga," Watford, Herts.

Historical and Scientific Society of Manitoba, Winnipeg, Canada.

Horniman Museum, Forest Hill, S.E.23. (The Curator).

Hull Scientific and Field Naturalists' Club, Royal Institution, Hull.

Illinois State Laboratory of Natural History (Library), Urbana, Ill., U.S.A.

Dr. V. A. Lathom, 1644, Morse Avenue, Rogers Park, Chicago, U.S.A.

Leicester Literary and Philosophical Society, Dr. Stracey, Hon. Librarian, Priory Lodge, New Walk, Leicester.

Library, Bureau of Science, Manila, Philippines.

Linnean Society, Burlington House, Piccadilly, W.1.

Literary and Philosophical Society of Manchester (The Librarian), 36, George Street, Manchester.

Lloyd Library, Cincinnati, Ohio, U.S.A.

Manchester Microscopical Society, 9, Poplar Road, Monson, near Manchester.

Microscopical Society of Liverpool, 19, Hockins Hey, Liverpool.

Missouri Botanical Garden, St. Louis, Mo., U.S.A.

Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne (The Librarian), Hancock Museum, Barras Bridge, Newcastle-upon-Tyne.

Natural History Branch of the British Museum (The Librarian), South Kensington, S.W.7.

Natural History Society of Glasgow (The Librarian), 207, Bath Street, Glasgow.
"Nature" (The Editor), St. Martin's Street, W.C.2.
Netherlands Zoological Society, Zoological Station, Helder, Holland.
"Nuova Notarisia," c/o Prof. G. B. De Toni, Université Royale de Modena, Modena, Italy.
"Nyt Magazin for Naturaidenskaberne," c/o Prof. Dr. N. Wille, Botan. Garten, Christiania.

Optical Society (The Hon. Librarian), 39, Victoria Street, S.W.1.

Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.2.
Philadelphia Academy of Natural Sciences, Philadelphia, Pa., U.S.A.
Philippine Exposition Board, Calle General Solano 384, Manila, Philippine Islands.

R. Scuola Superiore di Agricoltura, Portici, Italy.
Royal Dublin Society, Leinster House, Dublin.
Royal Institute of Cornwall, Truro.
Royal Institution, 21, Albemarle Street, W.1.
Royal Society of Medicine, 1, Wimpole Street, W.1.
Royal Microscopical Society, 20, Hanover Square, W.1.
Royal Society, Burlington House, Piccadilly, W.1.
Royal Society of New South Wales, Sydney.
Royal Society of Arts, John Street, Adelphi, W.C.2.

Smithsonian Institution, Washington, D.C.
Smithsonian Institution (United States National Museum), c/o Wm. Wesley & Son, 28, Essex Street, Strand, W.C.2.
Société Botanique Italienne, Florence, Italy.

Tempère, Mons. J., Villa Andrée Lucie, Cours Lamarque. Arcachon, France.
University of California Library (Exchange Department), c/o Wm. Wesley & Son, 28, Essex Street, Strand, London, W.C.2.

Victoria, Australia, Field Naturalists' Club of. A. D. Hardy, Hon. Secretary.

Wagner Free Institute, Montgomery Avenue and 17th Street, Philadelphia, U.S.A.

Wesenberg-Lund, Dr., Slotsgade, Hillerod, Denmark.

Wisconsin Academy of Sciences, Arts, and Letters (Exchange Secretary), Madison, Wis., U.S.A.